

Trice User Manual

+ Speed of Light `printf` Comfort Within Interrupts And Everywhere +
--> To Long; Don't Read – use it as reference only !

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1. Abstract

If you develop software for an embedded system, you need some kind of system feedback. Debuggers are awesome tools, but when it comes to analyze dynamic behavior in the field, they are not usable.

Logging then, usually done with printf-like functions, gets quick a result after having i.e. `putchar()` implemented. This turns out to be an expensive way in terms of processor clocks and needed FLASH memory, when you regard the library code and all the strings needing FLASH memory space. For small micro-controllers that's it.

Bigger micro-controllers are coming with embedded trace hardware. To use it, an expensive tool is needed. Useful for analyzing complex systems, but for in-field related issues at least unhandy.

Unhappy with this situation, the developer starts thinking of using digital pins or starts emitting some proprietary LED blinking codes or byte sequences, difficult to interpret.

The Trice technique tries to fill this gap, being minimal invasive for the target and as comfortable as possible. It is the result of a long-year dissatisfaction and several attempts to find a loophole to make embedded programming more fun and this way more effective.

Trice is an unusual software tracer-logger, using [internally](#) IDs instead of format strings to get maximum [speed](#) but provides the user with a printf-like comfort:

```
trice("Hello! 🙌😊 ");

int a = -4;
float x = 3.14159265;
trice("info:π/%d is %f with the bit pattern %032b\n", a, aFloat(x/a), x );

string s = "world";
triceS("msg:A runtime generated string: %s", s);
```

Replacing a `printf` library, the [Trice target source code](#) occupies 1-4 KB Flash [memory](#) and less than 1 KB RAM in dependence of the configuration which is done with a user file named `triceConfig.h`:

```
#define TRICE_DEFERRED_OUTPUT 1
#define TRICE_BUFFER TRICE_DOUBLE_BUFFER
#define TRICE_DEFERRED_UARTA 1
#define TRICE_UARTA USART2
```

The open-source Trice PC tool is executable on all [Go](#) platforms, at least:

- Linux
- MacOS
- Windows

In the future other ports are possible:

- C/C++ or Rust program to run on a separate controller board
- [Go-mobile](#)
- [tinyGo](#)
- [Wasm](#)
- [Phython](#)

```
TRICE8 1 2 3 4 5
TRICE8 1 2 3 4 5 6
TRICE8 1 2 3 4 5 6 6
```

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2. A brief history of Trice

Developing firmware means to deal also with interrupts and often with timing. How do you check, if an interrupt occurred? Ok, increment a counter and display it in a background loop with some `printf`-like function. What about time measurement? Set a digital output to 1 and 0 and connect a measurement device. Once, developing software for a real-time image processing device, I had no clue where in detail the processing time exploded when the image quality got bad. A spare analog output with a video interrupt synced oscilloscope gave me the needed information, after I changed the analog output on several points in my algorithm. But, hey guys, I want to deal with my programming tasks and do not like all this hassle connecting wires and steer into instruments.

A `printf` is so cool on a PC, developing software there. But an embedded device often cannot use it for performance reasons. My very first attempt was writing the format string `.const` offset together with its values in a FIFO during a log statement and to do the `printf` it in the background. But that is compiler specific. Ok the full string address is better but needs buffer space. [Zephyr](#) for example does something like that calling it "deferred logging".

Then, one day I had the idea to compute short checksums for the format strings in a pre-compile step and to use them as ID in a list together with the format strings. That was a step forward but needed to write a supporting PC program. I did that in C++ in the assumption to get it better done that way. Finally, it worked, but I hated my PC code, as I dislike C++ now because of all its nuts and bolts to handle, accompanied by missing libraries on the next PC. The tool usability was also unhandy and therefore error prone and the need became clear for a full automatized solution. Also, what is, if 2 different format strings accidentally generate the same short checksum? There was a way around, but an ID based message filtering will never be possible that way.

The need became clear for controllable IDs and management options. And there was [Go](#) now, an as-fast-as-C language, easy to learn, promising high programming efficiency and portability. It would be interesting to try it out on a real PC project.

Trying to add tags in form of partial Trice macro names was blowing up the header code amount and was a too rigid design. Which are the right tags? One lucky day I came to the conclusion to handle tags just as format string parts like "`debug:Here we are!\n`" and getting rid of them in the target code this way also giving the user [freedom](#) to invent any tags.

An other point in the design was the question how to re-sync after data stream interruption, because that happens often during firmware development. Several [encodings](#) where tried out and a proprietary escape sequence format and an alternative flexible data format with more ID bits where working reliable but with [COBS](#) things got satisfying. A side result of that trials is the Trice tool option to add different decoders if needed. Now the default Trice message framing is [TCOBSv1](#) which includes short message compression and this way allows very low transmit bandwidths and/or saves storage, when binary Trice data are stored in Flash memory.

There was a learning [not](#) to reduce the transmit byte count to an absolute minimum, but to focus more on Trice macro [speed](#) and universality. That led to a double buffer on the target side as an alternative to the ring buffer solution. The actual binary [encoding](#), allowing alongside user protocols, is result of the optional target timestamps and location info some users asked for, keeping the target code as light as possible. Float and double number support was implementable for free because this work is done mainly on the host side.

Trice grew, and as it got usable I decided to make it Open Source to say "Thank You" to the community this way.

Learning that Trice is also a [baby girl name](#), our daughter Ida designed the little girl with the pen symbolizing the Trice macro for recording and the eyeglasses standing for the PC tool Trice visualizing the logs.



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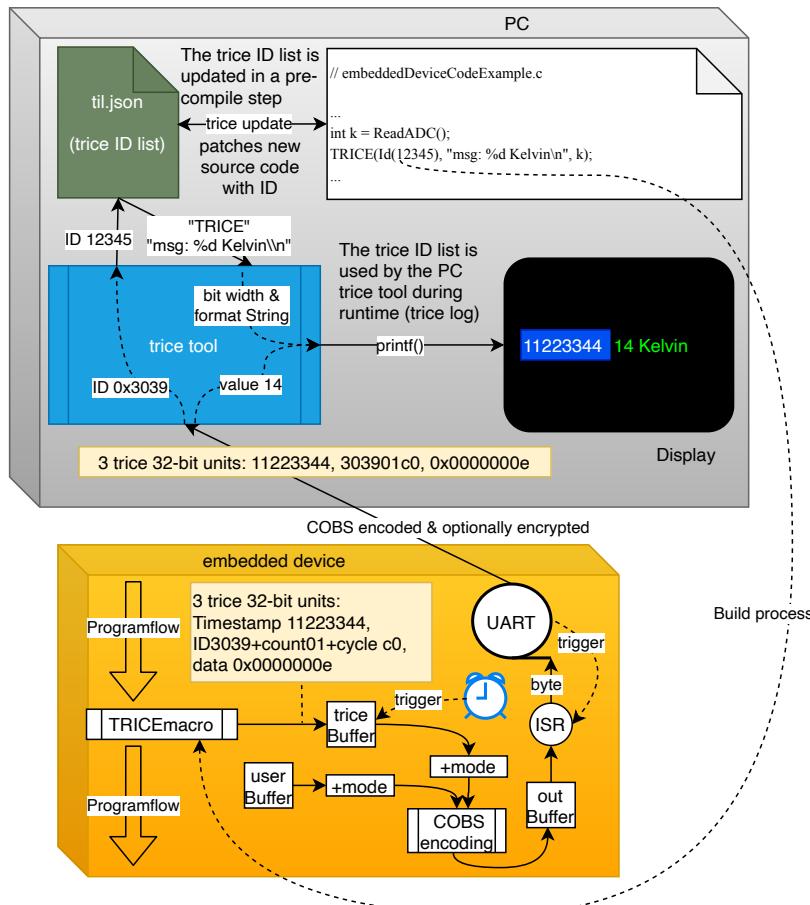
3. How it works - the main idea

Trice performs **no costly** printf-like functions on the target at all. The Trice macro, instead, just copies an ID together with the optional values to a buffer and is done. In the minimum case this can happen in **6(six!)** processor clocks even with target timestamps included. When running on a 64 MHz clock, **light can travel about 30 meters in that time**.

To achieve that, a pre-compile step is needed, executing a `trice insert` command on the PC. This is fast enough not to disturb the build process. The Trice tool parses then the source tree for macros like `trice("msg: %d Kelvin\n", k);` and patches them to `trice(id(12345), "msg: %d Kelvin\n", k);`, where `12345` is a generated 14-bit identifier (ID) copied into a [Trice ID List](#). During compilation than, the Trice macro is translated to the `12345` ID only, and the optional parameter values. The format string is ignored by the compiler.

The target code is [project specific](#) configurable. In **direct mode** the the stack or a static buffer is used as Trice buffer and the Trice macro execution includes optionally the quick [COBS](#) encoding and the data transfer. This more straightforward and slower architecture can be interesting for many cases because it is anyway much faster than printf-like functions calls. Especially when using [Trice over RTT](#) a single Trice is executable within ~100 processor clocks. See `TRICE_DIRECT_SEGGER_RTT_32BIT_WRITE` inside `triceDefaultConfig.h` and look into the [examples](#) folder. In **deferred mode** a service swaps the Trice double buffer or reads the Trice ring buffer periodically, the configured encoding, default is TCOBS, takes part and with the filled buffer the background transfer is triggered. Out buffer and Trice buffer share the same memory for efficiency.

During runtime the PC Trice tool receives all what happened in the last ~100ms as a package from the UART port. The `0x30 0x39` is the ID 12345 and a map lookup delivers the format string "`msg: %d Kelvin\n`" and also the bit width information. Now the Trice tool can write target timestamp, set msg color and execute `printf("%d Kelvin\n", 0x0000000e);`



The Trice tool is a background helper giving the developer focus on its programming task. The once generated ID is not changed anymore without need. If for example the format string gets changed into `"msg: %d Kelvin!\n"`, a new ID is inserted automatically and the reference list gets extended. Obsolete IDs are kept inside the [Trice ID List](#) for compatibility with older firmware versions. It could be possible, when merging code, an ID is used twice for different format strings. In that case, the ID inside the reference list wins and the additional source gets patched with a new ID. This maybe unwanted patching is avoidable with proper [Trice ID management](#). The reference list should be kept under source code control.

Moreover, using `trice i -cache && make && trice c -cache` in a build script makes the IDs invisible to the developer reducing the data noise giving more space to focus on the development task. See [build.sh](#) as a working example and the [Trice Cache](#) chapter for details.

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4. Trice Features (Overview)

4.1. Open source

Target code and PC tool are open source. The MIT license gives full usage freedom. Users are invited to support the further Trice development.

4.2. Easy-to-use

Making it facile for a user to use Trice was the driving point just to have

- one Trice tool
- one additional [target code](#) source folder
- a project specific simple to use [triceConfig.h](#)
- and to get away with the one macro [trice](#) for most situations.

Trice understands itself as a silent helper in the background to give the developer more focus on its real task. If, for example, [trice log](#) is running and you re-flash the target, there is **no need to restart** the Trice tool. When [til.json](#) was updated in an pre-build step, the Trice tool automatically reloads the new data during logging.

The Trice tool comes with many command line switches ([trice help -all](#)) for tailoring various needs, but mostly these are not needed. In file [./internal/args/tricehelpall_test.go](#) the expected test output contains this information as well.

Normal Trice tool usage is:

- `./build.sh` containing `trice insert -cache`, `make` and `trice clean -cache`
- `make log` containing `trice l -p COMn` for logging with default baud rate.

In this example, the user code gets **not** polluted with Trice IDs - they exists only during the compilation step and the Trice cache makes this invisible for the user and the build system.

4.3. Small size - using Trice frees FLASH memory

Compared to a printf-library code which occupies 1 to over 20 KB FLASH memory, the Trice code is normally **smaller** but provides full support.

4.4. Execution speed

Can it get faster than **6 clocks only**? Only 3 runtime Assembler instructions per Trice needed in the minimum case! Optional target timestamp, critical sections, cycle counter, diagnostics and overflow protection can consume a few more processor clocks, if enabled, but a Trice is still incomparable fast.

4.5. Robustness

When a Trice data stream is interrupted, the optional **COBS** or **TCOBS** encoding allows an immediate re-sync with the next COBS/TCOBS package delimiter byte and a default Trice **cycle counter** gives a high chance to detect lost Trice messages. See also [Versions and Variants Trice Stability](#).

4.6. Minimal Transfer Bytes Amount

A Trice message is 4 bytes long (2 ID bytes and 2 count bytes) plus optional time stamps and/or values. In conjunction with the compressing **TCOBS** framing the Trice data stream is as small as possible. Use the `-debug` switch to see the compressed and framed packages alongside the decompressed ones together with the decoded messages.

To see the encoding for each single message `#define TRICE_DEFERRED_TRANSFER_MODE TRICE_SINGLE_PACK_MODE` inside the project specific *triceConfig.h*.

Without `-debug` CLI switch:

```
ms@MacBook-Pro G0B1_inst % trice log -p /dev/tty.usbmodem0007722641261 -prefix off -li off -hs off -ts off
...
This is a message without values and without stamp.
...
```

With `-debug` CLI switch:

```
ms@MacBook-Pro G0B1_inst % trice log -p /dev/tty.usbmodem0007722641261 -prefix off -li off -hs off -ts off -debug
...
TCOBSv1: c1 74 e2 23 00
->TRICE: c1 74 e2 00
This is a message without values and without stamp.
...
```

The TCOBS encoding cannot compress in the example above, because the data are too small, but here is a significant compression result shown:

```
ms@MacBook-Pro G0B1_inst % trice log -p /dev/tty.usbmodem0007722641261 -prefix off -hs off -debug
...
TCOBSv1: b8 76 7b 18 84 fe e1 fd e1 fc e1 fb e1 fa e1 00
->TRICE: b8 76 7b 18 ff ff ff fe ff ff fd ff ff ff fc ff ff ff fb ff ff fa ff ff ff
 _test/testdata/triceCheck.c 805           value=-1, -2, -3, -4, -5, -6
...
```

- The **TRICE_SINGLE_PACK_MODE** inserts after each Trice a package delimiter **0**.
- The **TRICE_MULTI_PACK_MODE** inserts after a group of Trice messages a package delimiter **0**, what minimizes the transmit data amount.

When encryption is active, a compression makes no sense, but the **TRICE_MULTI_PACK_MODE** can help to reduce the total amount of padding bytes, because each encrypted package must have a multiple of 8 as length.

```
ms@MacBook-Pro G0B1_inst % trice log -p /dev/tty.usbmodem0007722641261 -prefix off -hs off -pw MySecret -pf cobs -debug
...
cobs: 21 84 b7 60 8b 21 89 1e e3 07 6d dc d9 2d 6f 59 04 8e 50 8f 24 1c a2 63 2e 3d 4a 57 ef 39 63 01
cb 00
->TRICE: 84 b7 60 8b 21 89 1e e3 07 6d dc d9 2d 6f 59 04 8e 50 8f 24 1c a2 63 2e 3d 4a 57 ef 39 63 01
cb
-> DEC: cc b6 63 01 71 02 ff fe cd 76 72 03 ff fe fd ce f6 64 81 00 00 73 04 ff fe fd fc 00 00 00 00
00
_test/testdata/triceCheck.c 827      0_355 value=-1, -2
_test/testdata/triceCheck.c 828      value=-1, -2, -3
_test/testdata/triceCheck.c 829      0,033_124 value=-1, -2, -3, -4
cobs: 19 50 70 79 d7 75 6f d7 99 dc d8 ec 06 e1 66 e7 a7 c1 0d 96 85 df 19 25 55 00
->TRICE: 50 70 79 d7 75 6f d7 99 dc d8 ec 06 e1 66 e7 a7 c1 0d 96 85 df 19 25 55
-> DEC: cf b6 64 01 74 05 ff fe fd fc fb d0 76 75 06 ff fe fd fc fb fa 00 00 00
_test/testdata/triceCheck.c 830      0_356 value=-1, -2, -3, -4, -5
_test/testdata/triceCheck.c 831      value=-1, -2, -3, -4, -5, -6
...

```

4.7. More comfort than printf-like functions but small differences

Trice is usable also inside interrupts and [extended format specifier possibilities](#) give options like binary or bool output. Transmitting runtime generated strings could be a need, so a `triceS` macro exists supporting the `%s` format specifier for strings up to 32737 bytes long. It is possible to log float/double numbers using `%f` and its relatives, but the numbers need to be covered with the fast converter function `aFloat(x)` or `aDouble(y)`. Also UTF-8 encoded strings are implicit supported, if you use UTF-8 for the source code. See chapter [Trice Similarities and differences to printf usage](#) for more details.

```
Jan 2 17:37:43.765791 COM11: triceCheck.c: 731 84800049 62936 TRICE64_1 double 518.0547492508867 (%G), aDouble(y)
Jan 2 17:37:43.765791 COM11: main.c: 157 84800051 40126 MSG: STOP select = 23, TriceDepthMax =1832
Jan 2 17:37:43.765791 COM11: main.c: 164 84800053 33395 84800052 µs - ReadUs() lasts 35 ticks
Jan 2 17:37:43.953268 COM11: main.c: 155 85000004 50543 MSG: START select = 24, TriceDepthMax =1832
Jan 2 17:37:43.953268 COM11: triceCheck.c: 734 85000006 45826 negative float & double
Jan 2 17:37:43.953268 COM11: triceCheck.c: 735 85000007 55265 TRICE float -1.089608e+03 (%e)
```

4.8. Tags, Color and Log Levels

You can label each Trice with a tag specifier to [colorize](#) the output. This is free of any runtime costs because the tags are part of the Trice log format strings, which are not compiled into the target. The Trice tool will strip full lowercase tag descriptors from the format string after setting the appropriate color, making it possible to give each letter its color.

Loggers use log levels and offer a setting like "log all above **INFO**" for example. The Trice tags can cover that but can do better: Inside package `emitter.ColorChannels` in a single file `./internal/emitter/lineTransformerANSI.go` all common log levels defined as Trice tags alongside with user tags. The user can adjust this. The Trice tool has the `-pick` and `-ban` switches to control the display in detail. Also a `-logLevel` switch is usable to determine a display threshold as tag position inside `ColorChannels`.

If an inside-target log selection is needed (routing), the Trice tool can assign each log tag a separate ID range and a target side ID based log selector can control which IDs are transmitted over which output channel. See chapter [Trice ID management](#) or type `trice help -insert` and look for `-IDRange`.

```
Nov 29 22:42:37.962401 COM7: 15747 AB:a:cde
Nov 29 22:42:37.962401 COM7: 15703 FGHIjk
Nov 29 22:42:37.962401 COM7: 15653 1234712123
```

4.9. Compile Time Enable/Disable Trice Macros on File or Project Level

After debugging code in a file, there is [no need to remove or comment out Trice macros](#). Write a `#define TRICE_OFF 1` just before the `#include "trice.h"` line and all Trice macros in this file are ignored completely by the compiler, but not by the Trice tool. In case of reconstructing the [Trice ID List](#), these no code generating macros are regarded.

```
#define TRICE_OFF 1 // Disable trice code generation for this file object.
#include "trice.h"
```

When you wish to build a firmware without any Trice code, it is sufficient to add

```
C_DEFS += -DTRICE_OFF=1 // Define TRICE_OFF=1 for the whole project.
```

or similar to your Makefile.

4.10. Target and host timestamps

For each Trice you can have (time) stamps or not:

- `trice("...", ...);` or `TRICE(id(0), ("...", ...))`: no stamp;
- `Trice("...", ...);` or `TRICE(Id(0), ("...", ...))`: 16-bit stamp;
- `TRice("...", ...);` or `TRICE(ID(0), ("...", ...))`: 32-bit stamp;

The optional 16- or 32-bit value carry than the system clock, a millisecond second or an other event counter configured in the project specific `triceConfig.h`. The Trice tool will automatically recognize and display the stamps in a mode you can control. If several Trice macros form a single line, the Trice tool only displays the target timestamp of the first Trice macro.

Embedded devices often lack a real-time clock and some scenarios can last for weeks. Therefore the Trice tool precedes each Trice line with a PC timestamp, if not disabled. This is the Trice reception time on the PC, what can be some milliseconds later than the target Trice event.

4.11. Target source code location

Some developers like to see the `filename.c` and `line` in front of each log line for quick source location. During `trice i` a file `li.json` is generated containing the location information. If `trice log` finds this file, filename and line number are displayed in front of each log line, otherwise not.

Because software is a matter of change it could happen you get obsolete information this way. Therefore the Trice tool log option `-showID` exists to display the Trice ID in front of each log line what gives a more reliable way for event localization in some cases. Also you can get it for free, because no target code is needed for that.

4.12. Several target devices in one log output

Several Trice tool instances can run parallel on one or different PCs. Each Trice tool instance receives *Trices* from one embedded device. Instead of displaying the log lines, the Trice tool instances can transmit them over TCP/IP (`trice l -p COMx -ds`) to a Trice tool instance acting as display server (`trice ds`). The display server can fold these log lines in one output. For each embedded device a separate Trice line prefix and suffix is definable. This allows comparable time measurements in distributed systems.

4.13. Any byte capable 1-wire connection usable

The usual Trice output device is an UART but also [SEGGER-RTT](#) is supported over J-Link or ST-Link devices. Many micro controller boards can act as Trice bridge to a serial port from any port ([Trice without UART](#)).

4.14. Scalability

The various [Trice ID management](#) options allow the organization also of bigger software systems. 16383 possible different IDs should match also large projects. Just in case: 16-bit for the ID is a not to hard changeable value.

4.15. Portability and Modularity

The Trice tool is written in the open source language [Go](#) and is therefore usable on many platforms. That means the automatic code patching and ID handling side with `trice insert`.

All C-compilers should be usable to compile the target Trice code and there is no hardware dependency despite the byte transmission. MCUs with 8-bit to 64-bit, little or big endian are supported.

Any user program able to read a [JSON](#) file, can receive the [documented](#) Trice message format, look-up the ID and perform a printf-like action to translate into log strings. The Trice tool with its `log` switch is a working example.

Using no framing, [COBS](#) or [TCOBS](#) packages starting with a [package descriptor](#) allows alongside user protocols. The other way around is also implementable: In a user protocol embedded [Trice](#) messages.

The Trice tool is expandable with several decoders. So it is possible to implement a minimal Trice encoding, if bandwidth matters heavily and control that with switches.

When less RAM usage is more important the target double buffer is replaceable with a ring buffer. So the user will be able to decide at compile time about that. A ring buffer mode is selectable inside `triceConfig.h` avoiding any buffer by paying a time toll.

The Trice tool supports [many command line switches](#).

4.16. Optional Trice messages encryption

The encryption opportunity makes it possible to test thoroughly a binary with log output and releasing it without the need to change any bit but to make the log output unreadable for a not authorized person. Implemented is the lightweight XTEA as option, what will do for many cases. It should be no big deal to add a different algorithm.

4.17. Trice Protection

When using Trice, data are written into buffers. A buffer overflow is impossible with the default configuration `#define TRICE_PROTECT 1` by simply ignoring possible overflow causing Trice statements. Those cases are not detectable by the cycle counter evaluation because non-existing Trice data on the embedded system cannot cause cycle errors. Therefore overflow error counters exists, which the user can watch. In [./examples/exampleData/triceLogDiagData.c](#) an option is shown. Of course this buffer overflow protection costs valuable execution time. If you prefer speed over protection, simply write into your project specific `triceConfig.h #define TRICE_PROTECT 0`.

4.18. Trice Diagnostics

A trice statement produces 4 bytes buffer data plus optional values data. When for example `TRice16("Voltage=%u\n")`, `x`; is called inside the ms system tick interrupt every 5th time, 10 bytes data are generated each 5 millisecond. This needs a transfer baudrate of at least 20.000 bit/s. A UART running at 115.200 baud can easily handle that. Anyway after 100 ms, a 200 Bytes buffer is filled and the question arises what is the optimal Trice buffer size. A caclulation is error prone, so measuring is better. So configure the buffer sizes bigger than estimated and watch the max depth of their usage. In [./examples/exampleData/triceLogDiagData.c](#) an option is shown. After you optimized your buffer sizes, you can deactivate the Trice diagnostics in your project specific `triceConfig.h` with `#define TRICE_DIAGNOSTICS 0`.

4.19. Trice Cache

One may think, automatically cleaning the IDs in the target code with `trice c` after building and re-inserting them just for the compilation needs file modifications all the time and a permanent rebuild of all files containing Trices will slow down the re-build process. That is true, but by using the Trice cache this is avoidable. Simply one-time create a `.trice/cache` folder in your home directory and use `trice insert -cache` and `trice clean -cache` in your `build.sh` script. More details you find in chapter [Trice Cache for Compilation Speed](#).

4.20. Avoiding False-Positive Editor Warnings

When the user writes

```
trice("msg: Hello! 🙌😊\n");
```

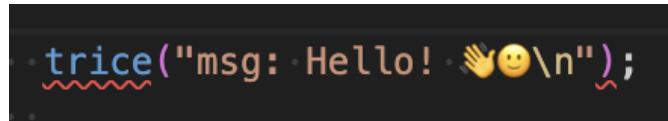
after `trice insert` this gets

```
trice(iD(123), "msg: Hello! 🙌😊\n");
```

and the compiler builds and then with `trice clean`, this gets again

```
trice("msg: Hello! 🙌😊\n");
```

Sophisticated editors may detect the missing ID and warn by underlining the trice command:



To avoid this you can add the following line to your project specific `triceConfig.h` file:

```
#define TRICE_CLEAN 1
```

The Trice tool, will change the value to 0 and change it back to 1, when performing the ID insertion and cleaning, when this line occurs inside the `triceConfig.h` file. This way these false-positive editor warnings are avoidable:

```
trice("msg: Hello! 🙌😊\n");
trice(iD(123), "msg: Hello! 🙌😊\n");
```

It is recommended to use the Trice cache in conjunction with this to avoid a permanent re-translation of files including Trice code.

4.21. Trice Generator

The Trice tool is able to generate colors or code to support various tasks. One interesting option is the Remote Procedure Call support, allowing RPC usage in a network of embedded devices.

Read chapter [Trice Generate](#) or type:

```
trice help --generate
```

4.22. Versions and Variants Trice Stability

When developing firmware, we get often different versions and variants in the developing process. When, for example, getting an older device back, it could be, we do not know the flashed firmware version at all. Because the Trice tool adds only IDs and their Trices to the project specific *til.json* file, the complete development history remains in that file. So connecting an old device to the Trice tool will deliver correct output. Of course the location information will be outdated. But when reading the Trice logs the compiled version should get visible and it is no big deal to get the corresponding *li.json* from the repository. If not, using the `-showID "%6d"` Trice log option displays the Trice IDs and you can easily grab the source code file and line.

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5. Project structure (Files and Folders)

name	content
<code>_test</code>	automatic target code tests
<code>.github/</code>	Github configuration
<code>.idea/</code>	GoLand settings
<code>.vscode/</code>	vsCode settings
<code>cmd/_cui/</code>	(do not use) command user interface tryout code
<code>cmd/_stim/</code>	(do not use) target stimulation tool tryout code
<code>cmd/trice</code>	Trice tool command Go sources
<code>docs</code>	documentation folder with link forwarding
<code>examples/</code>	example target projects
<code>internal/</code>	Trice tool internal Go packages
<code>pkg/</code>	Trice tool common Go packages
<code>src/</code>	C sources for trice instrumentation -> Add to target project
<code>super-linter.report/</code>	super linter output
<code>third_party/</code>	external components
<code>_config.yml</code>	jekyll configuration
<code>.clang-format</code>	See Trice Code Formatting
<code>.clang-format-ignore</code>	See Trice Code Formatting
<code>.editorconfig</code>	See Trice Code Formatting

name	content
.git/	version control data base (hidden)
.gitattributes	See Trice Code Formatting
.gitignore	Files git ignores
.goreleaser.yaml	goreleaser configuration
.travis.yml	Travis CI configuration
AUTHORS.md	contributors
CHANGELOG.md	History
CODE_OF_CONDUCT.md	How to communicate
CONTRIBUTING.md	Helper
go.mod	Go modules file
go.sum	Go modules sums
LICENSE.md	MIT
README.md	Github first page
coverage.out	Go test coverage output
dist/	local distribution files folder created by goreleaser
renewIDs_in_examples_and_test_folder.sh	renew all ID data
testAll.sh	run all tests

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6. Start with Trice

6.1. Get it

- Download [latest release assets](#) for your system: Compressed source code and binaries.
- OR Get the repo:
 - Create a Github Account
 - Create SSH key pair inside `~/.ssh/`: `ssh-keygen -t ed25510`
 - Add content of `~/.ssh/id_ed25519.pub` as SSH key to Github.
 - Execute `git clone git@github.com:rokath/trice.git` to get the trice repository.
- OR use the  button

6.2. Install It

- Place the extracted Trice [binary](#) somewhere in your [PATH](#).
- Copy the `src` folder into your project and add all files.
- Copy a `triceConfig.h` from a subfolder in the examples or test folder and optionally adapt it. See file `triceDefaultConfig.h` for help.
 - Inside the `triceConfig.h` file you can control, if Trice works in direct or deferred mode or both parallel.

6.3. Try it

- Create a file `tryTrice.c` and write in it:

```
#include "trice.h"

int tryIt( void ){
    trice( "Hello! 🙌😊\a\n" ); // A message with sound and without target timestamp.
}
```

You can also edit any of your existing project files accordingly. Just replace any `printf` with `trice`. (Handle float or double numbers and runtime-generated strings, according to [Trice Similarities and Differences to printf Usage](#). The file `_test/testdata/triceCheck.c` shows many usage examples. The uppercase Trice macros are inlining the complete Trice code and the lowercase Trice macros are function calls, so most probably you want use `trice` to keep the overall code size smaller.

- Create 2 empty files `til.json` and `li.json` in your project root.
- Run `trice insert` and the trice code line changes to `trice(iD(1234), "Hello! 🙌😊\a\n");`.
- The 2 JSON files are now filled with information.
- Run `trice clean` and the trice code line changes back to `trice("Hello! 🙌😊\a\n");`.

You can use `trice insert` as pre- and `trice clean` as post-compile step, to not spoil your source code with IDs.

The optional Trice cache technique avoids un-edited file changes at all, what means no Trice related build speed disadvantages.

See [Trice Cache for Compilation Speed](#) for more details and `examples/G1B1_inst/build.sh` as example.

- Or, use `trice insert` in a post-checkout and `trice clean` in a pre-check-in script to keep just the repository clean of Trice IDs. Using only `trice insert` as pre-compile step is possible too, especially when the code is used just in a single project and you wish to have it as compiled.
- When using Trice in libraries for several projects, it may make sense to check-in the libraries with IDs and to use a dedicated ID space for them. See `../_test/testdata/triceCheck.c` as an example - especially when building several projects parallel like shown in the examples folder.

A quick setup is possible when using RTT as output channel. Otherwise you need to setup a serial port for Trice data transmission. Other output paths possible too using the auxiliary interface.

6.4. Use It

- In a console, like `git bash`, type `trice help -all`. You should see the complete Trice tool CLI documentation.
 - Don't worry, most of it you will never need.
 - There are only 2 important commands: `trice insert` and `trice log`. Call them with the right CLI switches.

- `trice help -insert` and `trice help -log` show partial help.

- Examples:

CLI command	Description
<code>touch ./til.json</code>	Create an empty <code>til.json</code> file. This is needed only the very first time.
<code>trice i -src . -src ..//myLib</code>	Insert IDs to the current and your <code>..//myLib</code> folder. This will read extend modify <code>./til.json</code> and use & create the <code>./li.json</code> file.
<code>...</code>	Compile your project
<code>trice c -src . -src ..//myLib</code>	Optionally restore the current and your <code>..//myLib</code> folder. This will read extend modify <code>./til.json</code> and use & create the <code>./li.json</code> file.
<code>trice l -p com1 -baud 921600 -lf my/path/auto</code>	Start Logging over UART and create automatically a new log file in <code>my/path/</code> .
<code>cat filename.log</code>	View a recorded log file.
<code>trice l -p JLINK -args "..."</code>	Start Logging over RTT. Binary log files are collected in <code>./temp</code> .
<code>trice l -p FILEBUFFER - args logfile.bin</code>	Play a recorded binary log file.

- It is recommended to add `trice insert ...` as pre-compile step into the tool chain.
- Hint: It is possible to add `trice clean ...` as a post-compile step, so that you can check in your project sources without IDs. That is supported in v0.61.0 and later. This allows to use library sources with trices in different projects and the source code is not spoiled with IDs. The `-cache` CLI switch is recommended then. See [Trice Cache for Compilation Speed](#).

- The command `trice` does not make any assumptions about the target processor - 8-bit to 64-bit, supports little and big endianness.
- The command `trice` is compiler agnostic - it should work with any compiler.
- The vsCode editor is free downloadable and free usable, like shown in the `examples/F030_inst` project.
 - Even if you do not have such hardware, you can compile the `examples/F030_inst` project just to get started.

- When adding or modifying Trice macros inside `examples/F030_inst/Core/Src/main.c` and recompiling you should see automatically changed ID numbers inside the code.
- The examples and test sub-folders contains several vsCode Makefile projects and they are also usable as starting points for your configuration.
- You can use Trice calls also inside header files but when running `trice insert` as pre- and `trice clean` as post-compile step, all files including these headers will be re-compiled every time, what may be too time consuming. Enable the Trice cache then. See [Trice Cache for Compilation Speed](#) for more information.

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6.5. Port it

Trice should be usable on any MCU with any compiler. On ARM MCUs the easiest way is to use SEGGER J-Link with RTT as output. Setting up UART transmission as alternative or additionally is also no big deal.

Compare folders of one of these folder groups:

Without Instrumentation	With Trice Instrumentation	Remarks
<code>./examples/F030_bare</code>	<code>./examples/F030_inst</code>	no RTOS
<code>./examples/G0B1_bare</code>	<code>./examples/G0B1_inst</code>	FreeRTOS
<code>./examples/L432_bare</code>	<code>./examples/L432_inst</code>	FreeRTOS

This way you see in a quick way any needed adaptions for your target project to port trice to it.

The chapter [Example Projects without and with Trice Instrumentation](#) contains further helpful information.

6.5.1. Target Macros

The easiest and mostly sufficient way to use Trice on the target side is the Trice macro

```
trice("Hello world!"); // without      time stamp
Trice("Hello world!"); // with 16-bit time stamp
TRice("Hello world!"); // with 32-bit time stamp
```

which you can mostly use as a `printf` replacement in legacy code. See [Trice Similarities and differences to printf usage](#) for more details. It uses the `TRICE_DEFAULT_PARAMETER_BIT_WIDTH` value (usually 32), which is equal for all values.

The additional macros

- `trice8, trice16, trice32, trice64`
- `Trice8, Trice16, Trice32, Trice64`
- `TRice8, TRice16, TRice32, TRice64`

are always usable and the number 8, 16, 32, 64 specifies the parameter width, which is equal for all values within one macro. Trice macros are partially disabled, when the value `TRICE_SINGLE_MAX_SIZE` is defined to be smaller than 104. For example with `TRICE_SINGLE_MAX_SIZE == 8`, `TRice32` can have no parameter value (4 byte Trice header, 4 byte stamp) and `trice8` can have up to 4 parameter values (4 byte Trice header, 4 byte values). That's mainly to get compiler errors rather than runtime errors.

More examples:

Trice	Header	Stamp	max. Values	Trice Size
<code>trice8</code>	4	0	0 *1 byte	4
...
<code>trice8</code>	4	0	12 *1 byte	16
<code>Trice8</code>	4	2	0 *1 byte	6
...
<code>Trice8</code>	4	2	12 *1 byte	18
<code>TRice8</code>	4	4	0 *1 byte	8
...

Trice	Header	Stamp	max. Values	Trice Size
TRice8	4	4	12 *1 byte	20
trice16	4	0	2 *2 byte	8
Trice16	4	2	1 *2 byte	8
trice32	4	0	1 *4 byte	8
Trice32	4	2	1 *4 byte	10
TRice32	4	4	2 *4 byte	16
trice64	4	0	1 *8 byte	12
TRice64	4	4	1 *8 byte	16
...
TRice64	4	4	12 *8 byte	104

The value TRICE_DEFAULT_PARAMETER_BIT_WIDTH is the parameter bit width for the macros `trice`, `Trice`, `TRice` (without number). It can make sense to set this value to 16 on smaller machines.

The full uppercase macro Trice is a Trice macro only using inline code. Because the main design aim was speed, this was the original design. Then it became clear, that several hundred of Trice macros increase the needed code amount too much and that it is better to have just a function call instead of having inline macros. If speed matters use `TRICE(id(0)`, `TRICE(Id(0)`, `TRICE(ID(0)`) else use `trice(id(0)`, `Trice(id(0)`, `TRice(id(0)`) or mix usage as you like. The lower case macros internally use Trice like code but each is only a function call and therefore needs less space.

6.5.2. Target Trice Stamps

- If you wish to have your Trice messages stamped, most probably time stamped, add the 2 hardware specific macros/functions to your project (example in `./examples/F030_inst/Core/Inc/triceConfig.h` and `./examples/F030_inst/Core/Src/stm32f0xx_it.c`). The time base is in your hands and is allowed to be different for the 16-bit and 32-bit stamps. Example:

```
//! ms32 is a 32-bit millisecond counter, counting circular in steps of 1 every ms.
extern uint32_t ms32;
#define TriceStamp16 (SysTick->VAL) // Counts from 31999 -> 0 in each ms.
#define TriceStamp32 ms32
```

- In the code snippet above the 32-bit timestamp is used for milliseconds and the 16-bit timestamp is used as clock counter what allows fine grained time measurements.
- In the screenshot below, the 16-bit timestamp is a parallel counter running between 0-9999 milliseconds, which allows to have 16-bit timestamps all the time and only every 10 seconds is a full 32-bit timestamp needed.

```
Jan 14 17:38:22.112701 com6:      triceCheck.c: 729      6,710 TRICE32_4 4000000001 4000000002 4000000003 4000000004
Jan 14 17:38:22.113297 com6:      triceCheck.c: 730      0:00:26,720 TRICE64_1 ffffffff ffffffff ffffffff ffffffff
Jan 14 17:38:22.113882 com6:      triceCheck.c: 731      6,730 TRICE64_2 ffffffff ffffffff ffffffff ffffffff
Jan 14 17:38:22.114506 com6:      triceCheck.c: 732      6,740 TRICE64_1 18446744073709551615
Jan 14 17:38:22.115034 com6:      triceCheck.c: 733      6,750 TRICE64_2 18446744073709551615 18446744073709551614
Jan 14 17:38:24.104286 com6:      triceCheck.c: 934      TRICE32 with variable param count 1 to 12
Jan 14 17:38:24.104963 com6:      triceCheck.c: 935      0:00:28,770 TRICE32 -1
Jan 14 17:38:24.106075 com6:      triceCheck.c: 936      8,780 TRICE32 -1 -2
Jan 14 17:38:24.106698 com6:      triceCheck.c: 937      8,790 TRICE32 -1 -2 -3
```

- The trice tool `-ts*` CLI switches allow customization. With `-hs off` host time stamps are suppressed.
- It is also possible to use the stamp option not for time stamps but for any values, like addresses or a voltage or a random number.

Hint: I usually have the 32-bit timestamp as millisecond counter and the 16-bit timestamp as systick counter to measure short execution times.

6.5.3. Trice Checks

- Optionally copy parts of `./_test/testdata/triceCheck.c` to your project if you wish to perform some checks.
 - Do not include this file directly, because it could get changed when `updateTestData.sh` is executed inside the `./test` folder.
 - The only-uppercase `TRICE*` macros include trice code sequences what can lead to a significant code amount if you use plenty of them, whereas the lowercase macros `trice`, `Trice`, `TRice` and their relatives are just function calls and better suited to be used normally.

- In your source files add line `#include "trice.h"` at the top.
- In a function write a trice message like: `TRice("1/11 = %g\n", aFloat(1.0/11));`.
- In project root:
 - Create empty file: `touch til.json`.
 - `trice insert` should perform automatically the following things (The numbers are just examples.):
 - Patch source.c to `TRice(id(12363), "1/11 = %g\n", aFloat(1.0/11));`
 - C & H files containing Trice macros, are only modified if needed (missing IDs or changed format strings).
 - Extend `til.json`
 - If no `til.json` is found nothing happens. At least an empty file is needed (Safety feature).
- When the program runs later, it should output something similar to
 
- Look into [Trice Similarities and differences to printf usage](#) for options.
- Read chapter [Trice Project Image Size Optimization](#) if needed.

6.5.4. Communication Ports

- For RTT the [SEGGER](#) source is already included. See [Trice over RTT](#) for more info.
 - If RTT is used, no hardware specific adaptions needed and it is the fastest possible data transfer. But you cannot use it in the field usually.
 - The direct trice mode is recommended for RTT. The single trice execution is a bit longer then, but the log is completely done in one shot. It takes about 100-150 processor clocks, aka 1-2 microseconds.
 - Info: All deferred trice modes are faster in the runtime execution but the Trice logs appear slightly delayed. You can tune the Trices down to only 3 Assembler instructions **executable within 6 processor clocks**. See [Trice Speed](#) as example.
- For UART transfer add UART write functionality. The deferred mode is recommended for UART transfer.
- It is possible to log over several channels parallel and to select an ID range for each tag.
- An additional device, like local file, GPIO pin or SPI, is possible by providing an appropriate write functionality.
- See also [Trice without UART](#).

6.5.5. Target Code Overview

- [./src: User Interface](#)

File	description
<code>trice.h</code>	trice runtime lib user interface, <code>#include "trice.h"</code> in project files, where to use Trice macros. Add <code>./src</code> to your compiler include path.
<code>triceConfig.h</code>	Create this file to overwrite <code>triceDefaultConfig.h</code> as needed.

• [./src: Internal Components](#) (only partially needed, add all to your project - the configuration selects automatically)

File	description
<code>cobs.h</code>	message packaging, alternatively for tcobs
<code>cobsEncode.c</code>	message encoding, alternatively for tcobs
<code>cobsDecode.c</code>	message decoding, normally not needed
<code>trice.c</code>	trice core lib
<code>trice8McuOrder.h</code>	trice MCU endianness lib
<code>trice8McuReverse.h</code>	trice MCU reverse endianness lib
<code>trice16McuOrder.h</code>	trice MCU endianness lib
<code>trice16McuReverse.h</code>	trice MCU reverse endianness lib
<code>trice32McuOrder.h</code>	trice MCU endianness lib
<code>trice32McuReverse.h</code>	trice MCU reverse endianness lib
<code>trice64McuOrder.h</code>	trice MCU endianness lib
<code>trice64McuReverse.h</code>	trice MCU reverse endianness lib
<code>SEGGER_RTT.h</code>	Segger RTT code interface
<code>SEGGER_RTT.c</code>	Segger RTT code

File	description
tcobs.h	message compression and packaging interface
tcobsv1Encode.c	message encoding and packaging
tcobsv1Decode.c	message decoding and packaging, normally not needed
tcobsv1Internal.h	message decoding and packaging internal interface
trice8.h	8-bit trice code interface
trice8.c	8-bit trice code
trice16.h	16-bit trice code interface
trice16.c	16-bit trice code
trice32.h	32-bit trice code interface
trice32.c	32-bit trice code
trice64.h	64-bit trice code interface
trice64.c	64-bit trice code
triceAuxiliary.c	trice code for auxiliary interfaces
triceDefaultConfig.h	This file contains the most probably settings and serves also as a reference for tuning your project <i>triceConfig.h</i>
triceDoubleBuffer.c	trice runtime lib extension needed for fastest deferred mode
triceStackBuffer.c	trice runtime lib extension needed for direct mode
triceRingBuffer.c	trice runtime lib extension needed for recommended deferred mode
xtea.h	XTEA message encryption/decryption interface
xtea.c	XTEA message encryption/decryption code

- The *tcobs*** files are copied from <https://github.com/rokath/tcobs/tree/master/v1>. They are maintained there and extensively tested and probably not a matter of significant change.
- The SEGGER files are copied and you could check for a newer version at <https://www.segger.com/downloads/jlink/>.

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6.5.6. User Code Adaption

- Replace all strings `puts` with the string `trice`, when the string follows immediately. For runtime generated strings see `triceS`.
- Replace all strings `printf` with the string `trice`, when the format string follows immediately.
- Check for float and double format specifiers in the format strings. The appropriate parameters need to be covered with `aFloat()` or `aDouble()`. Example:

```
printf( "%d, %3.2f EUR, %g rate\n", i, price, change );
```

```
trice64( "%d, %3.2f EUR, %g rate\n", i, aFloat(price), aDouble(change) );
```

- Because double needs 8 bytes the trice macro in this case needs to be `trice64` (see [Trice Parameter Bit Widths](#)).
- Check for string format specifiers in the format strings. Put each in a separate trice message. Example:

```
printf( "name: %16s, surname: %32s, birthday: %4u-%02u-%02u\n", n, s, y, m, d);
```

```
trice( "name: %16s, ", n); trice( "surname: %32s, ", s ); trice( "birthday: %4u-%02u-%02u\n" y, m, d);
```

The Trice macros are designed for maximal execution speed and therefore we have to pay the price for their limited capabilities.

- Optionally add tags to get color. Example:

```
puts( "A message");
```

```
trice( "msg:A message");
```

- Add `#include trice.h` to all user files using trice.

6.5.7. Limitations

- The maximum parameter count per trice is 12, but buffer transfer allows up to 32764 bytes payload. See `triceB` and its relatives.
- Each trice must fit into a single line in trice versions before v0.61.0.
 - Not ok before v0.61.0 but ok for later versions:

```
trice( "hello %u\n",
       year);
```

- But several trices can be in one line.

- Ok:

```
trice( "hello %u\n", year); trice( "good time");
```

- Strings directly as parameter are possible now.

- Ok from v0.61.0 with `trice insert` and `trice clean`:

```
triceS( "hello %s\n", "world" );
```

- Ok always:

```
s = "world"; TRICE_S( "hello %s\n", s );
#define WORLD "world"
triceS( "hello %s\n", WORLD );
```

You should be aware that these parameter strings go into the target and slow down the execution. So, whenever a string is known at compile time it should be part of the Trice format string.

The Trice source code parser has very limited capabilities, so it cannot handle C-preprocessor string concatenation.

- Excluded trices are seen by the trice insert process.
 - Example: The following code will be patched and get an ID as well:

```
// trice( "Hi!" );
```

- All parameters inside one trice have the same bit width. If for example there are a single double and 10 bytes values, the needed trice macro is `trice64` providing 8 bytes space for all parameter values, therefore increasing the transmit overhead. With the default TCOBS framing the overhead is marginal because of the compression. Also this can be handled by splitting into 2 trices:

```
// 92 bytes: 4 bytes header plus 11 times 8 bytes
trice64( "%g: %c%c%c%c%c%c%c%c%", aDouble(3.14159), 61, 62, 63, 64, 65, 66, 67, 68, 69, 10 );

// 24 bytes: 4 bytes header plus 1 times 8 bytes plus 4 bytes header plus 8 times 1 byte
trice64( "%g: ", aDouble(3.14159)); trice8( "%c%c%c%c%c%c%c%", 61, 62, 63, 64, 65, 66, 67,
68, 69, 10 );
```

- See also [Avoid it](#).

6.5.8. Trice (Time) Stamps

- Trice messages can have no or 16-bit or 32-bit (time) stamps.

- recommended (function calling) syntax:

```
trice( "hello %u\n", year); // no (time) stamp
Trice( "hello %u\n", year); // 16-bit (time) stamp
TRice( "hello %u\n", year); // 32-bit (time) stamp
```

- legacy (inlining) syntax (usable for fastest execution):

```
TRICE( id(0), "hello %u\n", year); // no (time) stamp
TRICE( Id(0), "hello %u\n", year); // 16-bit (time) stamp
TRICE( ID(0), "hello %u\n", year); // 32-bit (time) stamp
```

6.5.9. Trice Parameter Bit Widths

- The macros `trice`, `Trice`, `TRice` and `TRICE` use 32-bit parameter values per default. See `TRICE_DEFAULT_PARAMETER_BIT_WIDTH` inside `src/triceDefaultConfig.h` to change that.
- If for example the bit width of all trice parameters is 8-bit, it is writable as `trice8` macro, reducing the transmitted byte count per parameter from 4 to 1:

```
char b[8] = {1,2,3,4,5,6,7,8};

// 36 bytes: 4 bytes plus 32 (8 times 4) bytes payload
trice( "%02x %02x %02x %02x %02x %02x %02x\n", b[0], b[1], b[2], b[3], b[4], b[5], b[6],
b[7]);` 

// 12 bytes: 4 bytes plus 8 (8 times 1) bytes payload
trice8( " %02x %02x %02x %02x %02x %02x %02x\n", b[0], b[1], b[2], b[3], b[4], b[5], b[6],
b[7]);` 

// 12 bytes: 4 bytes plus 8 (8 times 1) bytes payload in short notation.
triceB( "deb: %02x\n", &b, sizeof(b) );
```

Hint: With the default TCOBS framing 8-bit values as 32-bit parameters typically occupy only 2-bytes during transmission.

6.6. Avoid it

6.6.1. Parser Limitation

Because the implemented source code parser for `trice insert` and `trice clean` is only a simple one, there is one important limitation:

- Do not use an unescaped single double quote in source code comments. Example:

```
trice( "hi 0" );
// An "allowed" example comment.
trice( "hi 1");
// An \" allowed example comment.
trice( "hi 2");
```

```
// A " NOT allowed example comment. This disrupts the parsing.
trice( "hi 3");
// A " NOT allowed example comment. This enables the parsing after a disruption.
trice( "hi 4");
```

- The `trice insert` and `trice clean` will not see the `trice("hi 3");` line here, but the compiler will mark an error then.
- See also [issue #427](#), [issue #465](#) and see also [Limited Trice Parser Capabilities](#).

6.6.2. Trice macros in header files

- There is nothing wrong, when putting `trice` macros into header files.
- But: When you use `trice insert` as pre-build command and `trice clean` as post build command, those header files get touched on each build and therefore all source code files including them will be re-translated every time.
- For efficiency avoid that.
- **With inventing the Trice Cache this is of no relevance.**

6.6.3. Trice macros inside other macros

There is nothing wrong, when putting Trice macros into other macros. But: When running the self made macro, the location information of the inner `trice` macro will point to the self made macro definition and not to its execution location.

Example: When Functions fnA and fnB are executed, the MY_MESSAGE location information points to `file.h` and not into the appropriate lines inside `file.c`.

`file.h`:

```
#define MY_MESSAGE trice("msg:Hi\n"); // self made macro
```

`file.c`:

```
void fnA( void ){
    ...
    MY_MESSAGE
    ...
}

void fnB( void ){
    ...
    MY_MESSAGE
    ...
}
```

6.6.4. Upper case only TRICE macros should be written with id(0), Id(0) or ID(0)

The stamp size 0, 16 or 32 is usually controlled by writing `trice`, `Trice` or `TRICE` or for upper case only Trice macros by using `id(0)`, `Id(0)` or `ID(0)`. When wrting `TRICE("hi")`; for example, the Trice CLI switch `--defaultStampSize` controls the ID insertion, but this is then equal for all new `TRICE` messages.

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7. Trice Cache for Compilation Speed

The `trice insert` and `trice clean` commands are parsing and modifying the source code files. Even this is a reasonable fast procedure, this could get time consuming on large projects, especially when using these commands as permanent pre-compile and post-compile steps. It is assumed, that usually between 2 compile steps not all project files are changed. The project files majority will stay unchanged despite the ID insertion and removal. This repeated parsing and modifying of unchanged source code is avoidable with the Trice cache technique. Also it could get annoying to recompile files all the time only because they got Trice IDs removed and inserted. With the Trice cache we get also a solution not to re-compile un-edited files as well.

7.1. Trice Cache Idea

Lets talk about just one source file `$HOME/my/src/foo.c` and imagine we process many in one shot.

- On `trice insert foo.c`, get full path of `foo.c`, then: If `./trice/cache/cleaned/home/my/src/foo.c` exists and has the same modification time as `/home/my/src/foo.c`, copy `./trice/cache/inserted/home/my/src/foo.c` (if existing) to `/home/my/src/foo.c`. Otherwise insert IDs into `/home/my/src/foo.c` and afterwards copy it to `./trice/cache/inserted/home/my/src/foo.c`.
- On `trice clean foo.c`, get full path of `foo.c`, then: If `./trice/cache/inserted/home/my/src/foo.c` exists and has the same modification time as `/home/my/src/foo.c`, copy `./trice/cache/cleaned/home/my/src/foo.c` (if existing) to `/home/my/src/foo.c`. Otherwise remove IDs from `/home/my/src/foo.c` and copy it to `./trice/cache/cleaned/home/my/src/foo.c`.
- On any repeated or alternate `trice insert` and `trice clean`, we are done.
- When a file in cleaned or inserted ID state was edited somehow, its IDs are inserted/cleaned and the cache is updated accordingly on `trice clean` or `trice insert` because the file modification time has changed.

7.2. Trice Cache Logic

When `id.TriceCacheEnabled` is true (applied `-cache` CLI switch) and the folder `~/.trice/cache` exists, we have

- optionally a *cleaned cache file* `~/.trice/cache/cleaned/fullpath/file` with mtime of *IDs cleaned*
- optionally an *inserted cache file* `~/.trice/cache/inserted/fullpath/file` with mtime of *IDs inserted*
- fullpath/file** with mtime of *IDs cleaned OR IDs inserted OR last edit*. When mtime of `path/file` is:
 - IDs cleaned*:
 - On command `trice c`, nothing to do
 - On command `trice i`, copy, if existing, *inserted cache file* into `fullpath/file`. Otherwise process `trice i` and copy result into *inserted cache file*.
 - IDs inserted*:
 - On command `trice c`, copy, if existing, *cleaned cache file* into `fullpath/file`. Otherwise process `trice c` and copy result into *cleaned cache file*.
 - On command `trice i`, nothing to do
 - last edit*:
 - On command `trice c`, invalidate cache, process `trice c` and update *cleaned cache file*, file gets a new mtime, the mtime of *IDs cleaned*. On a following command `trice i`, file mtime is *IDs cleaned*, BUT the cache is invalid, so process `trice i` and update cache/inserted.
 - On command `trice i`, invalidate cache, process `trice i` and update *inserted cache file*, file gets a new mtime, the mtime of *IDs inserted*. On a following command `trice c`, file mtime is *IDs inserted*, BUT the cache is invalid, so process `trice c` and update cache/cleaned.

7.3. Trice Cache Remarks

- fullpath/file** means `/home/me/proj3/file` for example. When copied to the cache, the real "fullpath" is there `/home/me/.trice/cache/cleaned/home/me/proj3/file`.

Should the `.trice/cache` be better located inside the project folder? What, if the user has several projects and several users on the same machine working on projects together? What about libraries containing trice code?

- The `~/.trice/cache` folder should the Trice tool **not** create automatically in the users home folder `$HOME`. The existence of this folder is user controlled. The folder must exist. If several users work on the same project and some use the cache and some not - it is possible this way, even build scripts are shared.
- The `~/.trice/cache` folder should **not** go under revision control.
- A CLI switch `-cache` does enable/disable the Trice cache. Default is off.
- The user should consider what happens, if other pre-compile or post-compile steps are modifying files as well, before enabling the Trice cache.

7.4. Trice Cache Tests

Nr	Action	cCache	iCache	ID state	Edid state	Test function
0,1	0:clean	0:invalid	0:invalid	0:cleaned	X:any	Test_0_1_0000X_clean_on_invalid_cCache_invalid_iCache_cleaned_file
2,3	0:clean	0:invalid	0:invalid	1:inserted	X:any	Test_2_3_00011_clean_on_inalid_cCache_invalid_iCache_inserted_edited_file
4,5	0:clean	0:invalid	1:valid	0:cleaned	X:any	Test_4_5_0010X_clean_on_invalid_cCache_valid_iCache_cleaned_file
6	0:clean	0:invalid	1:valid	1:inserted	0:not	Test_6_00110_clean_on_invalid_cCache_valid_iCache_inserted_not_edited_file
7	0:clean	0:invalid	1:valid	1:inserted	1:yes	Test_7_00111_clean_on_invalid_cCache_valid_iCache_inserted_edited_file

Nr	Action	cCache	iCache	ID state	Edid state	Test function
8	0:clean	1:valid	0:invalid	0:cleaned	0:not	Test_8_01000_clean_on_valid_cCache_invalid_iCache_cleaned_not_edited_file
9	0:clean	1:valid	0:invalid	0:cleaned	1:yes	Test_9_01001_clean_on_valid_cCache_invalid_iCache_cleaned_edited_file
10	0:clean	1:valid	0:invalid	1:inserted	0:not	Test_10_01011_clean_on_valid_cCache_invalid_iCache_inserted_not_edited_file
11	0:clean	1:valid	0:invalid	1:inserted	1:yes	Test_11_01011_clean_on_valid_cCache_invalid_iCache_inserted_edited_file
12	0:clean	1:valid	1:valid	0:cleaned	0:not	Test_12_01100_clean_on_valid_iCache_valid_cCache_clean_file_not_edited
13	0:clean	1:valid	1:valid	0:cleaned	1:yes	Test_13_01101_clean_on_valid_iCache_valid_cCache_clean_file_edited
14	0:clean	1:valid	1:valid	1:inserted	0:not	Test_14_01110_clean_on_valid_iCache_valid_cCache_inserted_file_not_edited
15	0:clean	1:valid	1:valid	1:inserted	1:yes	Test_15_01111_clean_on_valid_iCache_valid_cCache_inserted_file_edited
16,17	1:insert	0:invalid	0:invalid	0:cleaned	X:any	Test_16_17_1000X_insert_on_invalid_cCache_invalid_iCache_cleaned_file
18,19	1:insert	0:invalid	0:invalid	1:inserted	X:any	Test_18_19_1001X_insert_on_invalid_cCache_invalid_iCache_inserted_edited_file
20,21	1:insert	0:invalid	1:valid	0:cleaned	X:any	Test_20_21_1010X_insert_on_invalid_cCache_valid_iCache_cleaned_file
22	1:insert	0:invalid	1:valid	1:inserted	0:not	Test_22_10100_insert_on_invalid_cCache_valid_iCache_inserted_not_edited_file
23	1:insert	0:invalid	1:valid	1:inserted	1:yes	Test_23_10101_insert_on_invalid_cCache_valid_iCache_inserted_edited_file
24	1:insert	1:valid	0:invalid	0:cleaned	0:not	Test_24_11000_insert_on_valid_cCache_invalid_iCache_cleaned_not_edited_file
25	1:insert	1:valid	0:invalid	0:cleaned	1:yes	Test_25_11001_insert_on_valid_cCache_invalid_iCache_cleaned_edited_file
26,27	1:insert	1:valid	0:invalid	1:inserted	X:any	Test_26_27_1010X_insert_on_invalid_cCache_valid_iCache_cleaned_file
28	1:insert	1:valid	1:valid	0:cleaned	0:not	Test_28_11100_insert_on_valid_cCache_valid_iCache_cleaned_not_edited_file
29	1:insert	1:valid	1:valid	0:cleaned	1:yes	Test_29_11100_insert_on_valid_cCache_valid_iCache_cleaned_edited_file
30	1:insert	1:valid	1:valid	1:inserted	0:not	Test_30_11110_insert_on_valid_cCache_valid_iCache_inserted_not_edited_file
31	1:insert	1:valid	1:valid	1:inserted	1:yes	Test_31_11111_insert_on_valid_cCache_valid_iCache_inserted_edited_file

7.5. Possible Trice Cache Editor-Issues And How To Get Around

- When a `trice i -cache && make && trice c -cache` sequence is executed, it could happen that the editor-view is not refreshed for opened and unedited files containing Trice statements.
 - It looks like the Trice IDs were not cleaned.
 - Closing and opening the file again shows, that the Trice IDs are indeed cleaned.
 - If the file is edited then without refreshing the view, that means with the shown Trice IDs, this is no problem, because after saving the edited file, it gets processed anyway, so no data loss is possible.
 - An automatic view refresh (close & open) for the editor could help here. But how to do that in an universal way?
- A workaround is, at least for vsCode, to first run `trice clean` in the build script.
 - See [trice/examples/G0B1_inst/build.sh](#) for an implementation.

7.6. Activating the Trice Cache

- Create Trice cache folder:

```
mkdir -p ~/.trice/cache
```

- Apply `-cache` CLI switch on `trice insert` and `trice clean`. See [./trice_insertIDs_in_examples_and_test_folder.sh](#) and [./trice_cleanIDs_in_examples_and_test_folder.sh](#) which both call [./trice_environment.sh](#) and used for example in [./examples/G0B1_inst/build.sh](#)
- Do **NOT** add the Trice cache to the version control.
- It is safe to `rm -rf ~/.trice/cache` and not to use the `-cache` CLI switch anymore.

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8. Trice Code Formatting

The file `./clang-format.sh` is used to auto-format the Trice code.

8.1. File .clang-format

Contributor: Sazerac4

Sazerac4 commented Aug 29, 2024: I have a code formatter when I make changes to my application but I would like to keep the style of the library when modifying. I couldn't find a code formatter, is there a tool used? If not, I propose this to provide one as an example by using clang-format.

```
## I have created a default style :
clang-format -style=llvm -dump-config > .clang-format
## Then format the code:
find ./src -name '*.*' -o -name '.*.h' | xargs clang-format-18 -style=file -i
```

The style of the example does not correspond to the original one. Configurations are necessary for this to be the case. Tags can be placed to prevent certain macros from being formatted

```
int formatted_code;
// clang-format off
void unformatted_code ;
// clang-format on
void formatted_code_again;
```

I have tuned some settings for clang-format :

```
* IndentWidth: 4 // original code size indentation
* ColumnLimit: 0 // avoid breaking long line (like macros)
* PointerAlignment: Left // like original files (mostly)
```

With preprocessor indentation, the result is a bit strange in some cases. It's possible with the option `IndentPPDirectives` ([doc](#)).

Staying as close as possible to a default version (LLVM in this case) makes it easier to regenerate the style if necessary.

See also: <https://github.com/rokath/trice/pull/487#issuecomment-2318003072>

8.2. File .clang-format-ignore

Contributor: Sazerac4

Sazerac4 commented Aug 30, 2024: I have added `.clang-format-ignore` to ignore formatting for specific files

8.3. File .editorconfig

Contributor: Sazerac4

The `.editorconfig` file allows to better identify the basic style for every files. (endline, charset, ...). It is a file accepted by a wide list of IDEs and editors : [link](#) This addition is motivated by forgetting the end of line in the `.gitattributes` file.

8.4. File .gitattributes

Contributor: Sazerac4

With the `.gitattributes` file avoid problems with "diff" and end of lines. [Here](#) is an article that presents the problem.

To fill the `.gitattributes`, I used the command below to view all the extensions currently used.

```
git ls-tree -r HEAD --name-only | perl -ne 'print $1 if m/\.(^.\/\.)+\$/' | sort -u
```

9. Build Trice tool from Go sources (you can skip that)

- Install [Go](#).

- Extend PATH variable with `~/go/bin`
- On Windows you need to install [TDM-GCC](#) if you wish to execute the CGO tests as well.
 - Take the 64-bit variant when Go is 64-bit or take the 32-bit variant when Go is 32-bit. If mixed installations work I doubt.
 - Recommendation: Minimal online installer.
 - GCC is only needed to test the target C-code on the host.
 - Make sure TDM-GCC is found first in the path, if you have several compilers installed.
 - Other gcc variants could work also but not tested.
- Open a console inside the Trice directory, recommended is the git-bash, when using Windows.
- Check and install:

```
ms@DESKTOP-7P0EGPB MINGW64 /c/repos/trice (master)
$ go clean -cache

ms@DESKTOP-7P0EGPB MINGW64 /c/repos/trice (master)
$ go vet ./...

ms@DESKTOP-7P0EGPB MINGW64 /c/repos/trice (master)
$ go test ./...
?     github.com/rokath/trice/cmd/cui [no test files]
ok    github.com/rokath/trice/cmd/stim      0.227s
ok    github.com/rokath/trice/cmd/trice     0.577s
ok    github.com/rokath/trice/internal/args  0.232s
ok    github.com/rokath/trice/internal/charDecoder 0.407s
ok    github.com/rokath/trice/internal/com    1.148s
ok    github.com/rokath/trice/internal/decoder   0.412s [no tests to run]
?     github.com/rokath/trice/internal/do      [no test files]
ok    github.com/rokath/trice/internal/dumpDecoder 0.388s
ok    github.com/rokath/trice/internal/emitter    0.431s
ok    github.com/rokath/trice/internal/id       0.421s
ok    github.com/rokath/trice/internal/keybcmnd 0.431s
ok    github.com/rokath/trice/internal/link     0.404s
ok    github.com/rokath/trice/internal/receiver 0.409s
ok    github.com/rokath/trice/internal/tleDecoder 0.398s
?     github.com/rokath/trice/internal/translator [no test files]
ok    github.com/rokath/trice/internal/trexDecoder 0.391s
ok    github.com/rokath/trice/pkg/cipher       0.377s
ok    github.com/rokath/trice/pkg/endian      0.302s
ok    github.com/rokath/trice/pkg/msg        0.299s
ok    github.com/rokath/trice/pkg/tst        0.406s
```

To execute the target code tests, you can run `testAll.sh` or `cd` into `_test` and run `go test ./...` from there. ATTENTION: These tests run a significant long time (many minutes depending on your machine), because the **Go - C** border is crossed very often. The last tests can last quite a while, depending on your machine.

```
ms@DESKTOP-7P0EGPB MINGW64 /c/repos/trice (master)
$ go install ./cmd/trice/
```

Afterwards you should find an executable `trice` inside `$GOPATH/bin/` and you can modify its source code.

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10. Embedded system code configuration

Check comments inside `triceDefaultConfig.h` and adapt your project configuration like shown in `triceConfig.h` as example.

A Trice macro is avoiding all the `printf()` internal overhead (space and time) but is nearly as easy to use. For example instead of writing

```
printf("time is %d:%d:%d\n", hour, min, sec);
```

you can write

```
trice8("time is %d:%d:%d\n", hour, min, sec);
```

into a source file of your project. The **8** stands here for 8 bit values (**16**, **32** and **64** also possible). Values of mixed size up to 32-bit size are allowed in one **trice** macro, so you can use Trice consequently to match most cases for the prize of little data overhead.

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11. Trice tool in logging action

With **trice log -port COM12** you can visualize the trices on the PC, if for example **COM12** is receiving the data from the embedded device at the 115200 default baudrate.

The following capture output comes from an (old) example project inside [..//examples](#).

```

Mar 12 18:59:29.261077: ISR:alive time 22816660 milliseconds
Mar 12 18:59:29.262078: ISR:alive time 22816670 milliseconds
Mar 12 18:59:29.264079: ISR:alive time 22816680 milliseconds
Mar 12 18:59:29.284098: ISR:alive time 22816690 milliseconds
Mar 12 18:59:29.286099: ISR:alive time 22816700 milliseconds
Mar 12 18:59:29.288101: timing message, SysTick is 33534 @ 22816706 ms
Mar 12 18:59:29.290103: Hello world this is a 1st printf replacement.
Mar 12 18:59:29.291104: 12345 as 16bit is 0b0011000000111001
Mar 12 18:59:29.293106: ----

Mar 12 18:59:29.294107: This ASSERT error is just a demo and no real error: triceCheck.c line 27 ERR:ASSERT failed
Mar 12 18:59:29.297109: ----

Mar 12 18:59:29.318129: TRICE8 %03x -> 001 07f -80 -01
Mar 12 18:59:29.320131: TRICE8 %4d -> 1 127 -128 -1
Mar 12 18:59:29.321131: TRICE8 %4o -> 1 177 -200 -1
Mar 12 18:59:29.323133: TRICE16 %05x -> 00001 07fff -8000 -0001
Mar 12 18:59:29.325135: TRICE16 %6d -> 1 32767 -32768 -1
Mar 12 18:59:29.327137: TRICE16 %7o -> 1 77777 -100000 -1
Mar 12 18:59:29.329139: TRICE32_4 %09x -> 00000001 07fffffff -80000000 -00000001
Mar 12 18:59:29.351158: TRICE32_4 %10d -> 1 2147483647 -2147483648 -1
Mar 12 18:59:29.354161: 64bit 0b100010010001000110011010001000101010101100110011011110001000
Mar 12 18:59:29.356163: TRICE8 -1
Mar 12 18:59:29.358165: TRICE8 -1 -2
Mar 12 18:59:29.359166: TRICE8 -1 -2 -3
Mar 12 18:59:29.360167: TRICE8 -1 -2 -3 -4
Mar 12 18:59:29.362168: TRICE8 -1 -2 -3 -4 -5
Mar 12 18:59:29.363169: TRICE8 -1 -2 -3 -4 -5 -6
Mar 12 18:59:29.385189: TRICE8 -1 -2 -3 -4 -5 -6 -7
Mar 12 18:59:29.387191: TRICE8 -1 -2 -3 -4 -5 -6 -7 -8
Mar 12 18:59:29.388192: TRICE16 -1
Mar 12 18:59:29.390194: TRICE16 -1 -2
Mar 12 18:59:29.391195: TRICE16 -1 -2 -3
Mar 12 18:59:29.392196: TRICE16 -1 -2 -3 -4
Mar 12 18:59:29.394198: TRICE32 -1
Mar 12 18:59:29.395199: TRICE32 -1 -2
Mar 12 18:59:29.397200: TRICE32 -1 -2 -3
Mar 12 18:59:29.418220: TRICE32 -1 -2 -3 -4
Mar 12 18:59:29.420221: TRICE64 -1
Mar 12 18:59:29.421222: TRICE64 -1 -2
Mar 12 18:59:29.423224: ERR:error message, SysTick is 21653
Mar 12 18:59:29.425226: WRN:warning message, SysTick is 21637
Mar 12 18:59:29.427228: ATT:attention message, SysTick is 21619
Mar 12 18:59:29.429230: DTADiagnostics message, SysTick is 21629
Mar 12 18:59:29.451249: TIM:timing message, SysTick is 21585
Mar 12 18:59:29.453251: DBG:debug message, SysTick is 21567
Mar 12 18:59:29.455253: SIG:signal message, SysTick is 21550
Mar 12 18:59:29.457255: RD:_read message, SysTick is 21532
Mar 12 18:59:29.458256: NR:_write message, SysTick is 21515
Mar 12 18:59:29.460258: TST:test message, SysTick is 21497
Mar 12 18:59:29.462260: MSG:normal message, SysTick is 21480
Mar 12 18:59:29.464261: error message, SysTick is 21462
Mar 12 18:59:29.485280: warning message, SysTick is 21445
Mar 12 18:59:29.487282: attention message, SysTick is 21427
Mar 12 18:59:29.489284: Diagnostics message, SysTick is 21404
Mar 12 18:59:29.491286: timing message, SysTick is 21390
Mar 12 18:59:29.493288: debug message, SysTick is 21372
Mar 12 18:59:29.495290: signal message, SysTick is 21355
Mar 12 18:59:29.497291: read message, SysTick is 21337
Mar 12 18:59:29.518311: write message, SysTick is 21320
Mar 12 18:59:29.520312: test message, SysTick is 21302
Mar 12 18:59:29.522314: normal message, SysTick is 21285
Mar 12 18:59:29.523315: ABC
Mar 12 18:59:29.525317:
Mar 12 18:59:29.526317: 1
Mar 12 18:59:29.527319: 12
Mar 12 18:59:29.528319: 123
Mar 12 18:59:29.529320: 1234
Mar 12 18:59:29.529320: 12345
Mar 12 18:59:29.530321: 123456
Mar 12 18:59:29.550339: 1234567
Mar 12 18:59:29.551341: 12345678
Mar 12 18:59:29.552341: 123456789
Mar 12 18:59:29.553342: 123456789a
Mar 12 18:59:29.554343: 123456789ab
Mar 12 18:59:29.555344: 123456789abc
Mar 12 18:59:29.556345: MSG:Berlin
Mar 12 18:59:29.557346: ----

Mar 12 18:59:29.558347: timing message, SysTick is 9383 @ 22816706 ms
Mar 12 18:59:29.560348: ISR:alive time 22816710 milliseconds
Mar 12 18:59:29.562350: ISR:alive time 22816720 milliseconds
Mar 12 18:59:29.564352: ISR:alive time 22816730 milliseconds

```

See [../test/testdata/triceCheck.c](#) for reference. The Trices can come mixed from inside interrupts (light blue `ISR:...`) or from normal code. For usage with a RTOS, Trices are protected against breaks (`TRICE_ENTER_CRITICAL_SECTION`, `TRICE_LEAVE_CRITICAL_SECTION`). Regarding the differences in the read SysTick values inside the GIF above These differences are the MCU clocks needed for one trice (~0,25µs@48MHz).

Use the `-color off` switch for piping output in a file. More convenient is the `-lf auto` switch.

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12. Encryption

- You can deliver your device with encrypted trices. This way only the service [wo]men is able to read the *Trices*.
- Implemented is `XTEA` but this is exchangeable.
- The to 8 byte padded blocks can get encrypted by enabling `#define ENCRYPT...` inside `triceConfig.h`. You need to add `-password MySecret` as `trice log` switch and you're done.
- Any password is usable instead of `MySecret`. Simply add once the `-show` switch and copy the displayed passphrase into the `triceConfig.h` file.
- The encryption takes part **before** the `COBS` encoding.
- TCOBS is usable but not recommended after encryption, because it cannot compress effective arbitrary data.

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13. Trice Command Line Interface & Examples

The trice tool is very easy to use even it has a plenty of options. Most of them normally not needed. The trice tool can be started in several modes (sub-commands), each with several mandatory or optional switches. Switches can have a single parameter string or not.

```
trice sub-command -switch1 -switch2 parameter -switch3 ...
```

Which sub-command switches are usable for each sub-command is shown with `trice help -all`. This gives also information about their default values.

Info for a special sub-command is shown with `trice help -log` for example.

- The command history is usable for example inside the bash, simply enter CTRL-R and start typing `trice...` and you can select from the history.
- The most convenient way is to use trice inside scripts like in [this](#) example.

13.1. Common information

- `trice h -all` shows all options of the current version.
- `trice ver` prints version information.
- `trice s` shows you all found serial ports for your convenience.
- `trice l -p COM17` could fail if something is wrong. Additional switches are for help tracking the issue:

- Use log switch `-s [howInputBytes]` to check if any bytes are received at all.

```
T.Hoehenleitner@DT-03023-TH MINGW64 /c/repos/trice.rokath (master)
$ trice l -p COM17 -s
Read ID List file C:\repos\trice.rokath\til.json with 1193 items.
Input(02 03 01 02 b7)
Input(10 b5 c6 45 fb bd 0b fd 01 6f c5 b6 03 2c 02 b9 10 b5 c6 4a fb bd 0b fe)
Input(01 be 9c b6 03 2c 02 c1 10 b5 c6 4c fb bd 0b ff 02 87 b8 4c fb bd 0b)
Input(1e 01 01 00 00 00)
Jan 23 21:59:29.600270 COM17: : 183 197000005 CYCLE: 253 not equal expected value 192 - adjusting. Now 0 CycleEvents
Jan 23 21:59:29.600270 COM17: MSG: START select = 950, TriceDepthMax = 556
Jan 23 21:59:29.600270 COM17: : 185 197000010 MSG: STOP select = 950, TriceDepthMax = 556
Jan 23 21:59:29.600270 COM17: : 193 197000012 197000012 µs - ReadUs32() lasts 30 ticks
 4 times: Timestamp tim time TIM TIME TIMESTAMP timestamp
 2 times: m msg message M MSG MESSAGE

T.Hoehenleitner@DT-03023-TH MINGW64 /c/repos/trice.rokath (master)
$ |
```

- With **-debug** you can see the [T]COBS packages and decoded Trice packages.

```
T:\Hochreitner07-03023-TH MINGW64 /c/repos/trice.rokath\til.json (master)
$ trice l -p COM17 -debug
Read ID List File C:\repos\trice.rokath\til.json with 1193 items.
COBS: 02 03 01 01 02 b7 10 b5 c6 45 bd a9 17 3d 01 6f c5 a2 03 2c 02 b9 10 b5 c6 4a bd a9 17 3e 01 be 9c a2 03 2c 02 c1 10 b5 c6 4c bd a9 17 3f 02 87 b8 4c bd a9 17 1e 01 01 00
-> PKG: 03 00 00 00 b7 00 b5 c6 45 bd a9 17 3d 01 6f c5 a2 03 2c 02 b9 00 b5 c6 4a bd a9 17 3e 01 be 9c a2 03 2c 02 c1 00 b5 c6 4c bd a9 17 3f 02 87 b8 4c bd a9 17 1e 00 00 00
TRICE --> 3d 01 6f c5 a2 03 2c 02
Jan 23 22:02:48.983634 COM17: : 183 397000005 CYCLE: 61 not equal expected value 192 - adjusting. Now 0 CycleEvents
Jan 23 22:02:48.983634 COM17: MSG: 🌿 START select = 930, TriceDepthMax = 556
TRICE --> 3e 01 be 9c a2 03 2c 02
Jan 23 22:02:48.984146 COM17: : 185 397000010 MSG: 🚧 STOP select = 930, TriceDepthMax = 556
TRICE --> 3f 02 87 b8 4c bd a9 17 1e 00 00 00
Jan 23 22:02:48.984146 COM17: : 193 397000012 397000012 μs - ReadUs32() lasts 30 ticks
COBS: 00
-> PKG:
COBS: 00
-> PKG:
COBS: 00 01 01 02 b7 10 b5 c6 85 ff b8 17 40 01 6f c5 ac 03 2c 02 b9 10 b5 c6 8a ff b8 17 41 01 be 9c ac 03 2c 02 c1 10 b5 c6 8c ff b8 17 42 02 87 b8 8c ff b8 17 1e 01 01 00
-> PKG: 03 00 00 00 b7 00 b5 c6 85 ff b8 17 40 01 6f c5 ac 03 2c 02 b9 00 b5 c6 8a ff b8 17 41 01 be 9c ac 03 2c 02 c1 00 b5 c6 8c ff b8 17 42 02 87 b8 8c ff b8 17 1e 00 00 00
TRICE --> 40 01 6f c5 ac 03 2c 02
Jan 23 22:02:49.983130 COM17: : 183 398000005 MSG: 🌿 START select = 940, TriceDepthMax = 556
TRICE --> 41 01 be 9c ac 03 2c 02
Jan 23 22:02:49.983638 COM17: : 185 398000010 MSG: 🚧 STOP select = 940, TriceDepthMax = 556
TRICE --> 42 02 87 b8 8c ff b8 17 1e 00 00 00
Jan 23 22:02:49.984148 COM17: : 193 398000012 398000012 μs - ReadUs32() lasts 30 ticks
COBS: 00
-> PKG:
COBS: 00
-> PKG:
COBS: 00 01 01 02 b7 10 b5 c6 c5 41 c8 17 43 01 6f c5 b6 03 2c 02 b9 10 b5 c6 ca 41 c8 17 44 01 be 9c b6 03 2c 02 c1 10 b5 c6 cc 41 c8 17 45 02 87 b8 cc 41 c8 17 1e 01 01 00
-> PKG: 03 00 00 00 b7 00 b5 c6 c5 41 c8 17 43 01 6f c5 b6 03 2c 02 b9 00 b5 c6 ca 41 c8 17 44 01 be 9c b6 03 2c 02 c1 00 b5 c6 cc 41 c8 17 45 02 87 b8 cc 41 c8 17 1e 00 00 00
TRICE --> 43 01 6f c5 b6 03 2c 02
Jan 23 22:02:50.976596 COM17: : 183 399000005 MSG: 🌿 START select = 950, TriceDepthMax = 556
TRICE --> 44 01 be 9c b6 03 2c 02
Jan 23 22:02:50.977143 COM17: : 185 399000010 MSG: 🚧 STOP select = 950, TriceDepthMax = 556
TRICE --> 45 02 87 b8 cc 41 c8 17 1e 00 00 00
Jan 23 22:02:50.977143 COM17: : 193 399000012 399000012 μs - ReadUs32() lasts 30 ticks
COBS: 00
-> PKG:
COBS: 00
-> PKG:
12 times: Timestamp tim time TIME TIMESTAMP timestamp
 6 times: m msg message M MSG MESSAGE
```

- trice i** in the root of your project parses all source files for Trice macros, adds automatically ID's if needed and updates a file named **til.json** containing all ID's with their format string information. To start simply generate an empty file named **til.json** in your project root. You can add **trice i** to your build process and need no further manual execution.
- trice ds** starts a display server listening on default ip address **127.0.0.1:61487** or any specified value. This is possible also on a remote device, lets say with ip address **192.168.1.200**.
- trice l -p COM18 -ds** sends the log strings to a display server with default ip address **127.0.0.1:61487** or any specified value, if for example **-ipa 192.168.1.200** the trice logs go to the remote device. You can start several trice log instances, all transmitting to the same display server.

13.2. Further examples

13.2.1. Automated pre-build insert command example

- Scan directories **../src**, **../lib/src** and **./** to insert the IDs there and extend list file **../../../../til.json**

```
trice i -v -i ../../til.json -src ../src -src ../lib/src -src ./
```

This is a typical line you can add to your project as an automatic pre-compile step.

13.2.2. Some Log examples

- Log trice messages on COM3 8N1 115200 baud

```
trice log -i ./myProject/til.json -p=COM3
```

- Log trice messages on COM3 8N1 9600 baud and use default til.json

```
trice l -s COM3 -baud=9600
```

13.2.3. Logging over a display server

- Start displayserver on ip 127.0.0.1 (localhost) and port 61497

```
trice ds
```

- Log trice messages on COM3 and display on display server

```
trice l -ds -p COM3
```

- Shutdown remote display server on IP 192.168.1.23 port 45678

```
trice sd -r 192.168.1.23:45678
```

13.2.4. Logfile output

```
trice l -p COM3 -logfile auto
```

This creates a new logfile `2022-05-16_2216-40_trice.log` with the actual timestamp on each Trice start.

```
trice l -p COM3 -logfile trice.log
```

This creates a new logfile `trice.log` on first start and appends to it on each next Trice start.

Logfiles are text files one can see with 3rd party tools. Example: `cat trice.log`. They contain also the PC reception timestamps if where enabled.

13.2.5. Binary Logfile

```
trice l -p COM3 -binaryLogFile auto
```

This creates a new binary logfile `2022-05-16_2216-40_trice.bin` with the actual timestamp on each Trice start.

```
trice l -p COM3 -binaryLogFile trice.bin
```

This creates a new binary logfile `trice.bin` on first start and appends to it on each next Trice start.

Binary logfiles store the Trice messages as they come out of the target in binary form. They are much smaller than normal logfiles, but the Trice tool with the `til.json` is needed for displaying them and the PC timestamps are the displaying time: `trice l -p FILEBUFFER -args trice.log`.

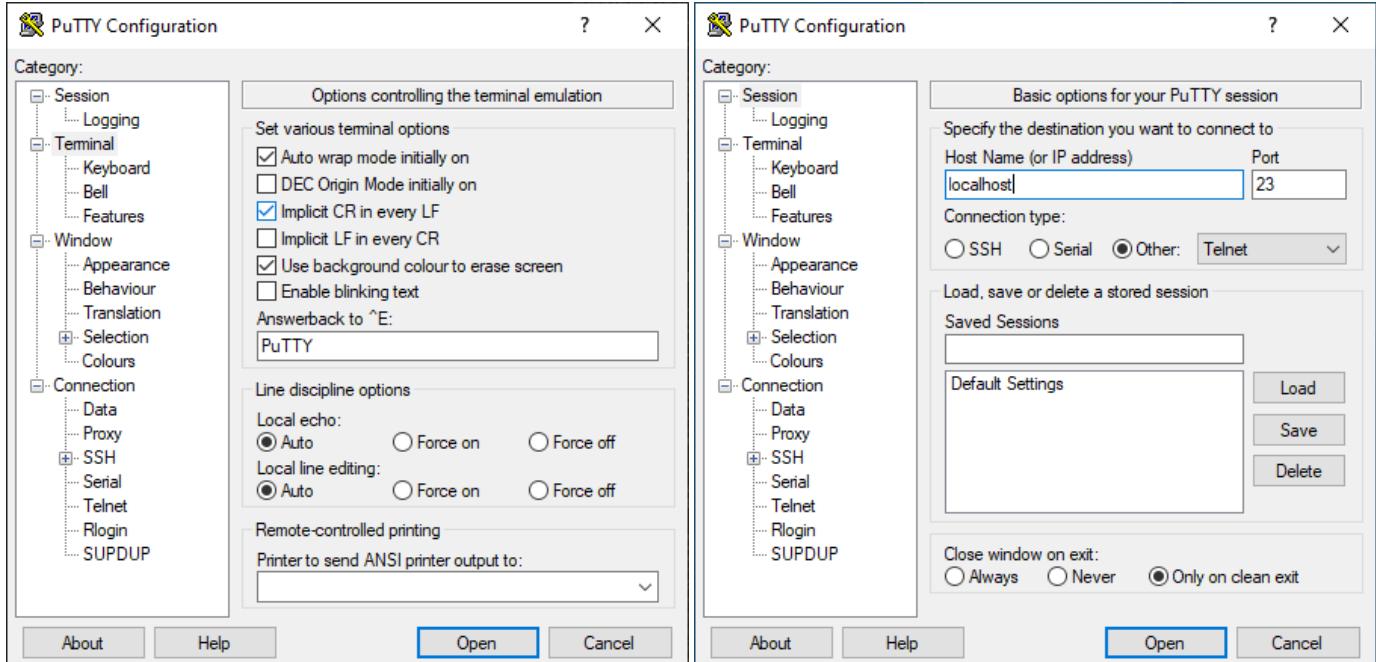
Binary logfiles are handy in the field for long data recordings.

When using RTT, the data are exchanged over a file interface. These binary logfiles are stored in the project `[./temp]` folder and accessable for later view: `trice l -p FILEBUFFER -args ./temp/logfileName.bin`. Of course the host timestamps are the playing time then.

13.2.6. TCP output

```
trice l -p COM3 -tcp 127.0.0.1:23
```

This additionally sends Trice output to a 3rd party TCP listener, for example like Putty:



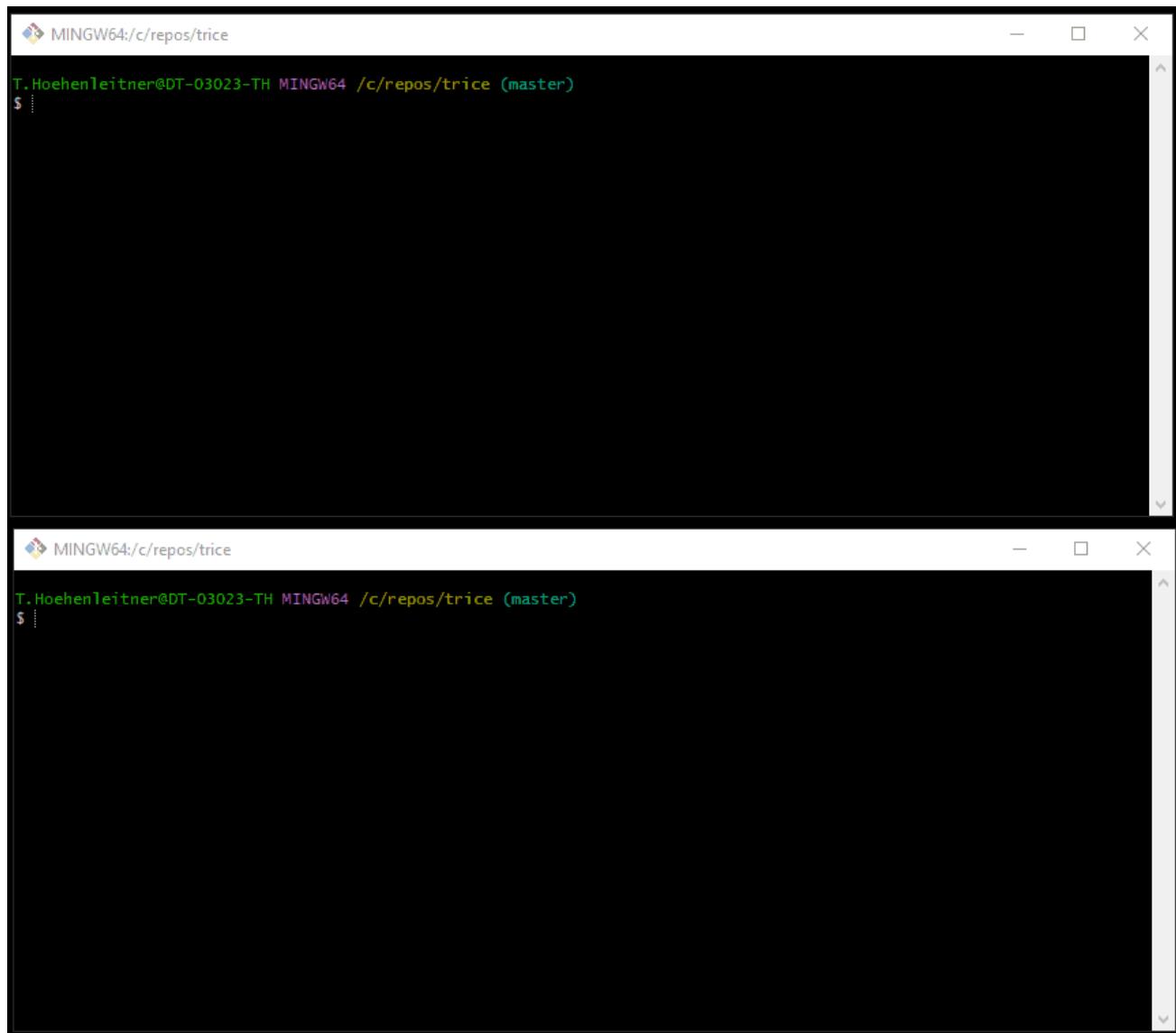
13.2.7. TCP input

```
trice l -p TCP4 -args "192.168.2.3:45678"
```

This expects a TCP4 server at IP address 192.168.2.3 with port number 45678 to read binary Trice data from.

13.2.8. Stimulate target with a user command over UART

Sometimes it is handy to stimulate the target during development. For that a 2nd screen is helpful what is possible using the display server option:



13.2.9. Explore and modify tags and their colors

See chapter [Trice Tags and Color](#).

13.2.10. Location Information

When running `trice insert`, a file `li.json` is created, what you can control with the `-li|locationInformation` switch. During logging, when `li.json` is found, automatically the filename and line number is displayed in front of each log line, controllable with the `-liFmt` switch. This information is correct only with the right version of the `li.json` file. That is usually the case on the PC during development. Out in the field only the `til.json` reference is of importance. It serves as an accumulator of all firmware versions and usually the latest version of this file is the best fit. The `li.json` file should stay with the software developer only and needs no version control in the usual case because it is rebuild with each compilation, when `trice i` is a prebuild step. When `trice clean` is used, the file `li.json` should go into the version management too to secure that identical trices get the same ID back.

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14. Limitations

14.1. Permanent Limitations

14.1.1. Limitation TRICE in TRICE not possible

- No-Good Example:

```
int f0( void ){ TRICE( "msg:f0\n"); return 0; }
void f1( void ){ TRICE( "No; %d", f0() ); }
```

- This will compile normally but corrupt TRICE output.

The reason is: When `f1()` gets active, the "No" Trice header is created, than the `f0()` Trice is executed and afterwards the "No" Trice tail is written. This works well during compile time but causes a mismatch during runtime.

- Workaround:

```
int f0( void ){ TRICE( "msg:f0\n"); return 0; }
void f1( void ){ int x = f0(); TRICE( "Yes: %d", x ); }
```

14.2. Current Limitations

14.2.1. String Concatenation Within TRICE Macros Not Possible

String concatenation within TRICE macros does not work. The reason lays inside the way the trice tool parser works:

```
void f0( void ){ TRICE( "msg:" ## "Hello\n" ); } // ERROR!
```

To implement this would need to build a trice preprocessor or to run the C preprocessor first and to modify the preprocessor output with the trice tool. That would make things unnecessary complicate and fragile for now.

14.2.2. Limited Trice Parser Capabilities

The Trice tool internal parser has only limited capabilities. It works well in most cases, but could lead to problems in some cases. The compiler run will for sure end up with some error messages in the following examples, so the developer can fix the code.

An example, provided by [@KammutterSpule](#), is this:

- started from an empty `li.json`/`til.json`

```
void trice0_test() {
    Trice0( "OK" );
    Trice( InvalidUse );
    Trice( "OK", Variable );
}
```

- run `trice insert`

```
void trice0_test() {
    Trice0( iD(2740), "OK"); // ok, id is added
    Trice( InvalidUse ); // no warning or error
    Trice( "OK", Variable ); // id is not added / inserted
}
```

As said, the compiler will complain about that in any case.

14.2.3. Special Care Demands

More than 12 printf parameters

- use several printf-calls
- Use triceB and its relatives

Float Numbers

- surround each with `aFloat()`

Double numbers

- surround each with `aDouble()` and use the `trice64` macro and relatives

Runtime Generated Strings

- Each needs its own `triceS` macro, example:

- Legacy code:

```
printf( "Entered name is %20s %30s, favorite numbers %d, %f\n", "Paul", "Luap", 42, 3.14159
);
```

- Trice code:

```
name = "Paul"; triceS( "Entered name is %20s", name );
surname = "Luap"; triceS( " %30s, ", surname );
trice( "favorite numbers %d, %f\n", 42, aFloat(3.14159) );
```

The `triceS` macro is ment to be used with strings not known at compile time.

Usage intention and recommendation: (given by [@escherstair](#))

```
char dynamic_string[50];
fillDynamicStringFromSomewhere(dynamic_string); // the content of dynamic_string is filled at run time
triceS( "msg:This part of the string is known at compile time. This part is dynamic: %s\n",
dynamic_string);
```

All the string literals (i.e. compile-time known strings) should be put inside the format string. Only the dynamic strings should be used as variables in `triceS` macro for best performance.

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15. Additional hints

15.1. Pre-built executables are available

See <https://github.com/rokath/trice/releases>.

15.2. Configuration file `triceConfig.h`

- When setting up your first project you need a `triceConfig.h` file.
- You should **not** use the `./_test/cgo.../triceConfig.h` directly, because these are customized for internal tests with CGO. But you can use their settings as helper for a starting point.
- Please choose one of these files as starting point:
 - `../examples/F030_inst/Core/Inc/triceConfig.h`
 - `../examples/G0B1_inst/Core/Inc/triceConfig.h`
 - `../examples/L432_inst/Core/Inc/triceConfig.h`
- Comparing them and understandig the differences helps quick starting.
- The file `triceDefaultConfig.h` contains all possible config keys with descriptions.

15.3. Setting up the very first connection

If you see nothing in the beginning, what is normal 😊, add the `-s (-showInputBytes)` switch to see if any data arrive. There is also a switch `-debug` showing you the received packages, if you are interested in.

15.4. Avoid buffer overruns

It is your responsibility to produce less data than transmittable. If this is not guarantied, a data loss is not avoidable or you have to slow down the user application. The buffers have an optional overflow protection (`TRICE_PROTECT`), which is enabled by default. Recommendation: Make the buffer big and emit the maxDepth cyclically, every 10 or 1000 seconds. Then you know the needed size. It is influenced by the max Trice data burst and the buffer switch interval. See `./examples/exampleData/triceLogDiagData.c` for help.

If the target application produces more Trice data than transmittable, a buffer overrun can let the target crash, because for performance reasons no overflow check is implemented in versions before v0.65.0. Such a check is added now per default using `TRICE_PROTECT`, but the Trice code can only throw data away in such case. Of course you can disable this protection to get more speed.

Configuring the ring buffer option with `TRICE_PROTECT == 0` makes buffer overruns not completely impossible, because due to partial Trice log overwrites, false data are not excluded anymore and overwriting the buffer boundaries is possible, because of wrong length information. Also losses will occur when producing more data than transmittable. This is detectable with the cycle counter. The internal 8-bit cycle counter is usually enabled. If Trice data are lost, the receiver side will detect that because the cycle counter is not as expected. There is a chance of 1/256 that the detection does not work for a single case. You can check the detection by unplugging the trice UART cable for a time. Also resetting the target during transmission should display a cycle error.

Gennerally it is recommended to enable `TRICE_PROTECT` during development and to disable it for performance, if you are 100% sure, that not more data are producable than transmittable.

Important to know: If the `TRICE_PROTECT` code inhibits the writing into a buffer, there will be later no cycle error because a non existing Trice cannot cause a cycle error. Therefore the `TriceDirectOverflowCount` and `TriceDeferredOverflowCount` values exist, which could be monitored.

15.5. Buffer Macros

(Examples in `./_test/testdata/triceCheck.c`)

Macro Name	Description
<code>triceS TriceS TRiceS TRICE_S</code>	Output of runtime generated 0-terminated strings.
<code>triceN TriceN TRiceN TRICE_N</code>	Is for byte buffer output as string until the specified size. It allows limiting the string size to a specific value and does not rely on a terminating 0. If for example len = 7 is given and "Hello\0World\n" is in the buffer, the byte sequence "Hello\0W" is transmitted but the trice tool probably shows only "Hello".
<code>trice8B Trice8B TRice8B TRICE8_B</code>	Is for byte buffer output according to the given format specifier for a single byte.
<code>trice16B Trice16B TRice16B TRICE16_B</code>	Is for 16-bit buffer output according to the given format specifier for a 16-bit value.
<code>trice32B Trice32B TRice32B TRICE32_B</code>	Is for 32-bit buffer output according to the given format specifier for a 32-bit value.
<code>triceB TriceB TRiceB TRICE_B</code>	Is buffer output according to the given format specifier for a default unit according to configuration (8 16 32 64-bit value) - default is <code>#define TRICE_B TRICE8_B</code> .

15.6. Logfile viewing

Logfiles, Trice tool generated with sub-command switch `-color off`, are normal ASCII files. If they are with color codes, these are ANSI escape sequences.

- Simply `cat trice.log`. One view option is also `less -R trice.log`. The Linux command `less` is also available inside the windows git bash.
- Under Windows one could also download and use `ansifilter` for logfile viewing. A monospaced font is recommended.
- See also [Color issues under Windows](#)

15.7. Using the Trice tool with 3rd party tools

Parallel output as logfile, TCP or binary logfile is possible. See examples above.

15.8. Several targets at the same time

You can connect each target over its transmit channel with an own Trice instance and integrate all transmissions line by line in an additional Trice instance acting as display server. See <https://github.com/rokath/trice#display-server-option>.

The C-code is executed during some tests. Prerequisite is an installed GCC.

15.9. TRICE_STACK_BUFFER could cause stack overflow with -O0 optimization

As discussed in [issue #294](#) it can happen, that several TRICE macros within one function call increase the stack usage more than expected, when compiler optimization is totally switched off.

15.10. Cycle Counter

- The trice tool expects the first cycle counter to start with 0xC0 (=192). If the target is already running and you connect the trice tool then, the first message is marked with "CYCLE: ? not equal expected value 192 - adjusting. Now 1 CycleEvents".
- If the target is reseted asynchronous, the trice tool receives a cycle counter 192. Most probably the last cycle counter was not 191, so this triggers also a message with "CYCLE: 192 not equal expected value ? - adjusting. Now n CycleEvents".
- In the Trice tool is some heuristics to suppress such obvious false positives.

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16. Switching Trice ON and OFF

16.1. Target side compile-time Trice On-Off

- If your code works well after checking, you can add `#define TRICE_OFF 1` just before the `#include "trice.h"` line and no Trice code is generated anymore for that file, so no need to delete or comment out Trice macros:

```
#define TRICE_OFF 1
#include "trice.h"
void fn(void) {
    trice(iD(123), "Hi"); // Will generate code only, when TRICE_OFF == 0.
    trice("Lo");           // Will generate code only, when TRICE_OFF == 0.
}
```

With `#define TRICE_OFF 1`, macros in this file are ignored completely by the compiler, but not by the Trice tool. In case of re-constructing the [Trice ID List](#) these no code generating macros are regarded and go into (or stay inside) the ID reference list.

- Hint from [@escherstair](#): With `-D TRICE_OFF=1` as compiler option, the trice code disappears completely from the binary.
- No runtime On-Off switch is implemented for several reasons:
 - Would need a control channel to the target.
 - Would add little performance and code overhead.
 - Would slightly change target timing (testing).
 - User can add its own switches anywhere.
 - The short Trice macro code is negligible.
 - The trice output is encryptable, if needed.
- Because of the low Trice bandwidth needs and to keep the target code as clear as possible the runtime On-Off decision should be done by the Trice tool.

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16.2. Host side Trice On-Off

- The PC Trice tool offers command line switches to `-pick` or `-ban` for Trice tags and will be extended with display switches.
- A Trice tool `-logLevel` switch is usable too.

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17. Framing

- Trice messages are framed binary data, if framing is not disabled.
- Framing is important for data disruption cases and is done with **TCOBS** (has included data compression) but the user can force to use **COBS**, what makes it easier to write an own decoder in some cases or disable framing at all.
 - Change the setting **TRICE_FRAMING** inside **triceConfig.h** and use the Trice tool **-packageFraming** switch accordingly.
- For robustness each Trice can get its own (T)COBS package (**TRICE_DEFERRED_TRANSFER_MODE == TRICE_SINGLE_PACK_MODE**). That is configurable for transfer data reduction. Use **#define TRICE_DEFERRED_TRANSFER_MODE TRICE_MULTI_PACK_MODE** inside **triceConfig.h** (is now default). This allows to reduce the data size a bit by avoiding many 0-delimiter bytes but results in some more data loss in case of data disruptions.

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18. Optional XTEA Encryption

- If XTEA is used, the encrypted packages have a multiple-of-8 byte length containing 1-7 padding bytes.
- The optional decryption is the next step after unpacking a data frame.
- Enabling XTEA, automatically switches to COBS framing. There is no need to use the Trice tool **-packageFraming** switch in that case because the Trice tool, when getting the CLI switch **-password "phrase"** automatically assumes COBS encoded data, overwriting the default value for **-packageFraming**.

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19. Endianness

- To interpret a decoded package, it's endianness needs to be known.
- For efficiency, binary trice data are normally stored and transmitted in MCU endianness and the Trice tool expects binary data in little endian format as most MCUs are little endian.
- On big endian MCUs the compiler switch **TRICE MCU IS BIG_ENDIAN** needs to be defined as 1 and **TRICE_TRANSFER_ORDER_IS_BIG_ENDIAN** should have the same value. The Trice tool has a CLI switch "triceEndianness" which needs to be set to "bigEndian" then.
- If trice transmit data are needed to be not in MCU order for some reason, that increases the critical trice storage time and target code amount.
- De facto different values for **TRICE MCU IS BIG_ENDIAN** and **TRICE_TRANSFER_ORDER_IS_BIG_ENDIAN** are mainly used to test the Trice CLI switch **-triceEndianness bigEndian** automatically.

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20. Trice (Time)Stamps

- Each Trice message can carry stamp bits, which are free usable like for time, addressing or filtering.
- By selecting the letter case (**trice**, **Trice**, **TRice**) you decide for each single Trice macro about the stamp size.
- Default notation (function call):

notation	stamp size	remark
trice(id(n), "...", ...);	0-bit	no stamp at all, shortest footprint
Trice(id(n), "...", ...);	16-bit	calls internally uint16_t TriceStamp16(void) for trice message stamping
TRice(id(n), "...", ...);	32-bit	calls internally uint32_t TriceStamp32(void) for trice message stamping

- No upper case macro, like **TRICE_S** works with the internal **id(n)** macro. They need **id(n)**, **Id(n)** or **ID(n)**. See next table.
- Legacy notation (code inlining):

notation	stamp size	remark
TRICE(id(n), "...", ...)	0-bit	no stamp at all, shortest footprint
TRICE(Id(n), "...", ...)	16-bit	calls internally uint16_t TriceStamp16(void) for trice message stamping
TRICE(ID(n), "...", ...)	32-bit	calls internally uint32_t TriceStamp32(void) for trice message stamping

It is up to the user to provide the functions `TriceStamp16` and/or `TriceStamp32`. Normally they return a `μs` or `ms` tick count but any values are allowed.

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21. Binary Encoding

21.1. Symbols

Symbol	Meaning
<code>i</code>	ID bit
<code>I</code>	<code>iiiiiiii</code> = ID byte
<code>n</code>	number bit
<code>z</code>	count selector bit
<code>s</code>	stamp selector bit
<code>N</code>	<code>znnnnnnnn</code> = count selector bit plus 7-bit number byte
<code>c</code>	cycle counter bit
<code>C</code>	<code>z==0 ? cccccccc : nnnnnnnn</code> = cycle counter byte or number byte extension
<code>t</code>	(time)stamp bit
<code>T</code>	<code>tttttttt</code> = (time)stamp byte
<code>d</code>	data bit
<code>D</code>	<code>dddddddd</code> = data byte
<code>...</code>	0 to 32767 data bytes
<code>"..."</code>	format string
<code>W</code>	bit width 8, 16, 32 or 64 (<code>uW</code> stands for <code>u8</code> , <code>u16</code> , or <code>u64</code>)
<code>X</code>	unspecified bit
<code>X</code>	<code>=xxxxxxxx</code> unspecified byte

21.2. Package Format

- Because of the **TCOBS** or **COBS** package framing, the package sizes are detectable by the trice tool without additional length information.
- All decoded frames of 0-, 1-, 2- and 3-byte size are considered as user data and ignored by the Trice tool.

bytes	Comment
<code>..</code>	This is an empty package, which can have also a meaning. It is detectable by 2 consecutive 0-delimiter bytes.
<code>X</code>	1-byte message, reserved for extensions or user data
<code>XX</code>	2-byte message, reserved for extensions or user data
<code>XXX</code>	3-byte message, reserved for extensions or user data

- In decoded frames with ≥ 4 -bytes the first 2 bytes contain 2 stamp selector bits at the most significant position in the known endianness.
- The `0` stamp selector is usable for any user encoding. The Trice tool ignores such packages.
- The `1`, `2` and `3` stamp selector bits are followed by the 14-bit ID.

16-bit groups	Stamp Selector (2 msb)	Comment	Endianness sizes
<code>00xxxxxxxx ...</code>	0	≥ 4 -byte message, reserved for extensions or user data	<code>u16 ?...?</code>
<code>01iiiiii NC ...</code>	1	≥ 4 -byte message, Trice format without stamp	<code>u16 u16 [uW] ... [uW]</code>

16-bit groups	Stamp Selector (2 msb)	Comment	Endianness sizes
_____ 10iiiiii TT NC ... _____	2	>= 4-byte message, Trice format with 16-bit stamp	____ u16 u16 u16 [uW] ... [uW]
10iiiiii 10iiiiii TT NC ... _____	2	First 16bit are doubled. Info over -d16 trice switch.	u16 u16 u16 u16 [uW] ... [uW]
_____ 11iiiiii TT TT NC ... _____	3	>= 4-byte message, Trice format with 32-bit stamp	____ u16 u32 u16 [uW] ... [uW]

- The stamp selector 2 encoding has 2 possibilities. When using `TRICE_DIRECT_SEGGER_RTT_32BIT_WRITE` or encryption, for alignment reasons the first 16bit ID field is doubled. The trice tool discards these 2 doubled bytes when the CLI switch `-d16` is given or encryption is active.
- Default endianness is little endian as most MCUs use little endianness. Otherwise the `-triceEndianness=bigEndian` CLI switch is needed.
- The receiving tool evaluates firstly the 2 stamp bits and follows some rules:
 - 0: reserved -> ignore the whole package (discard) or treat it as user data.
 - 1: next 14 bits are the ID followed by 2 bytes u16=NC and optional parameter values. Package size is >= 4 bytes.
 - 2 and `-d16` CLI switch not provided: next 14 bits are the ID and convert then u16=TT=stamp16 followed by 2 bytes u16=NC and optional parameter values. Package size is >= 6 bytes.
 - 2 and `-d16` CLI switch provided: next 14 bits are the ID, discard 2 following bytes and convert then u16=TT=stamp16 followed by 2 bytes u16=NC and optional parameter values. Package size is >= 8 bytes.
 - 3: next 14 bits are the ID and convert then u32=TTTT=stamp32 followed by 2 bytes u16=NC and optional parameter values. Package size is >= 8 bytes.
- use ID to get parameters width `W`=8,16,32,64 from file `til.json` and and parameters count and convert appropriate.
 - Within one trice message the parameter bit width `W` does not change.

Framing with COBS or TCOBS encoding

- For maximum storage speed each Trice message starts at a 32-bit boundary and has 1-3 padding bytes.
- In direct mode only a single message needs handling.
- In deferred mode after double buffer swap any count of trice messages is in the buffer.
- There are different policies possible:
 - TRICE_MULTI_PACK_MODE:** Compact buffer by removing all padding bytes, encode it as a single package, append one 0-delimiter and transmit. This allows to reduce the transmitted data amount by paying the price of possibly more data lost in case of an error. Also the data interpretation can perform less checks.
 - TRICE_SINGLE_PACK_MODE:** Encode each buffer separate, append a 0-delimiter for each and pack them all together before transmitting. This increases the transmit data slightly but minimizes the amount of lost data in case of a data disruption.

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22. Trice Decoding

The 14-bit IDs are used to display the log strings. These IDs are pointing in two reference files.

22.1. Trice ID list til.json

- This file integrates all firmware variants and versions and is the key to display the message strings. With the latest version of this file all previous deployed firmware images are usable without the need to know the actual firmware version.
- The files `til.h` and `til.c` are generated to help writing an own trice decoder tool in your preferred language. Use `trice generate -tilH -tilC` for creation. That can be interesting in environments, where Go compiled binaries not executable, like PCs running QNX OS. See also chapter [Trice Generate](#).

22.2. Trice location information file li.json

- If the generated `li.json` is available, the Trice tool automatically displays file name and line number. But that is accurate only with the exact matching firmware version. That usually is the case right after compiling and of most interest at the developers table.
- The Trice tool will silently not display location information, if the `li.json` file is not found. For in-field logging, the option `-showID "inf:%5d"` could be used. This allows later an easy location of the relevant source code.

- An other option is to record the binary trice messages (`trice log -p com1 -blf aFileName`) and to play them later with the Trice tool using the correct `li.json` (`trice log -p FILEBUFFER -args aFileName`).
- The user has the possibility to change the default kind of the location information path. Normally it is "base" and just the source code file names, containing Trice macros occur inside the `li.json` file. That is sufficient as long there are no files with identical names on different places possibly containing identical Trices. Then it is not guaranteed that the same IDs are always assigned. For such cases "relative" or "full" is selectable for the location information path kind (CLI `-liPath`). But both have weaknesses: The "full" path can differ between different machines and "relative" can differ between different projects on the same PC. Again: we are talking here about identical Trice messages in files with identical names and the worst happening is that these "exchange" their IDs between `trice insert && trice clean && trice insert`. When using the Trice cache even less inconsistencies are expected.
 - The Trice folder itself is an example, how to deal with several projects and user library code. The "user libraries" here are inside `./_test/testdata` and `./examples/exampleData`. The "user projects" are the folders `./examples/*_inst/`. You can take the `*.sh` scripts as examples how to deal with such case.

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23. Trice ID Numbers

23.1. ID number selection

- The default encoding TREX supports 14-bit IDs, so over 16000 IDs possible. Other encodings can work with other ID sizes.
- `trice("Hi!\n");` → `trice i` → `trice(id(12345), "Hi!\n");` → `trice c` → `trice("Hi!\n");`
- The **ID 12345** is a number assigned to `trice("Hi!\n");` in the above example.
 - It is a so far unused number, according to rules you can control:
 - The `-IDMethod` switch allows a selection method for new IDs.
 - Per default new IDs determined randomly to keep the chance low, that several developers grab the same ID.
 - Example: `trice insert -IDMin 1000 -IDMethod upward` will choose the smallest free ID ≥ 1000 .
 - This allows to use the ID space without wholes.
 - The `-IDMin` and `-IDMax` switches are usable to control the ID range, a new ID is selected from, making it possible to divide the ID space. Each developer can get its region.
 - Example: `trice insert -IDMin 6000 -IDMax 6999` will choose new randomly IDs only between 6000 and 6999.
 - It is possible to give each Trice tag an **ID** range making it possible to implement Trice tag specific runtime on/off on the target side if that is needed. This could be interesting for routing purposes also. Please run `trice help -insert` and read about the `-IDRange` switch for more details.

23.1.1. Trice tool internal Method to get fast a random ID

- Create Slice with numbers 1...16383
- Remove all used ID numbers from this slice
- Get random number between 0 and `len(slice)`
- remove this ID from slice and use it as new ID

23.2. ID number usage and stability

- If you write `trice("msg:%d", 1);` again on a 2nd location, the copy gets a different **ID**, because each Trice gets its own **ID**.
- If you change `trice("msg:%d", 1);` to `trice8("msg:%d", 1);`, to reduce the needed parameter space, a new **ID** is assigned. That is because the parameter bit width is implicit a part of the now changed Trice. If you change that back, the previous **ID** is assigned again.
- If you change `trice("msg:%d", 1);` to `TRice8("msg:%d", 1);`, to get a 32-bit stamp, the associated **ID** remains unchanged. That is because the optional stamp is not a part of the Trice itself.
- IDs stay constant and get only changed to solve conflicts.
- To make sure, a single ID will not be changed, you could change it manually to a hexadecimal syntax.
 - This lets the `trice insert` command ignore such Trice macros and therefore a full `til.json` rebuild will not add them anymore. Generally this should not be done, because this could cause future bugs.
 - It is possible to assign an ID manually as decimal number. It will be added to the ID list automatically during the next `trice i|c` if no conflicts occur.
- If a Trice was deleted inside the source tree (or file removal) the appropriate ID stays inside the ID list.
- If the same string appears again in the same file this ID is active again.
- If a trice occurs more than one time, each occurrence gets a different ID. If then 2 of them disappear, their ID numbers stay in `til.json`. If then one of them comes back, it gets its ID back.

23.3. Trice ID 0

- The trice ID 0 is a placeholder for "no ID", which is replaced automatically during the next `trice insert` according to the used trice switches `-IDMethod`, `-IDMin` and `IDMax`.

- It is sufficient to write the **TRICE** macros just without the `id(0)`, `Id(0)`, `ID(0)`. It will be inserted automatically according the `-defaultStampSize` switch. With `trice clean` these stay with 0-values in the source code to encode the intended stamp size.
- It is recommended to use the `trice`, `Trice` and `TRice` macros instead of `TRICE`. They encode the stamp size in their names already. There may be cases, where the user prefers to use the code inserting macros `TRICE` to get maximum performance.

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24. Trice ID management

24.1. Trice inside source code

24.1.1. Trice in source code comments

- Trice macros commented out, are **visible** for the `trice insert` command and therefore regarded.
 - Example: `// trice("Hi!\n");` is still regarded by the `trice i`.
- During `trice insert` commented out Trice macros, are treated in the same way as active Trice macros. Even after deletion their content stays inside `til.json`. This is intentionally to get best stability across several firmware versions or variants.
- The `trice` tool does treat `trice` statements inside comments or excluded by compiler switches also.

24.1.2. Different IDs for same Trices

- When the same Trice is used several times with identical IDs, after copying, and `trice insert` is called, only one ID survives in the source code. The other Trices get assigned new IDs. Otherwise the location information would not be correct everywhere.

24.1.3. Same IDs for different Trices

- If duplicate ID's with different format strings found inside the source tree (case several developers or source code merging) one ID is replaced by a new ID. The probability for such case is low, because of the default random ID generation.
- Also you can simply copy a Trice statement and modify it without dealing with the ID.
- The `trice` tool will detect the 2nd (or 3rd) usage of this ID and assign a new one, also extending the ID list.
- That is done silently for you during the next `trice insert`.
- When you use the `Trice Cache`, the IDs are invisible and all happens in the background automatically.

24.1.4. ID Routing

With the `Trice` insert CLI switch `-IDRange` each `Trice tag` can get a specific ID range assigned and inside the project specific `triceConfig.h` the user can control, which ID range is routed to specific output channels. Search for `_MIN_ID` inside `triceDefaultConfig.h` and extend your search than for example `TRICE_UARTA_MIN_ID` to explore how to use.

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25. ID reference list `til.json`

- The `trice insert` command demands a `til.json` file - it will not work without it. That is a safety feature to avoid unwanted file generations. If you are sure to create a new `til.json` file, create an empty one: `touch til.json`.
- The name `til.json` is a default one. With the command line parameter `-i` you can use any filename.
- It is possible to use several `til.json` files - for example one for each target project but it is easier to maintain only one `til.json` file for all projects.
- The ID reference list keeps all obsolete IDs with their format strings allowing compatibility to former firmware versions.
- One can delete the ID reference list when IDs inside the code. It will be reconstructed automatically from the source tree with the next `trice clean` command, but history is lost then.
- Keeping obsolete IDs makes it more comfortable during development to deal with different firmware variants at the same time.

25.1. `til.json` Version control

- The ID list should go into the version control repository of your project.
- To keep it clean from the daily development garbage one could `git restore til.json`, and re-build just before check-in.

--> For the `no-ids` option deleting `til.json` should not be done when the sources are without IDs.
--> That would result in a loss of the complete ID history and a assignment of a complete new set of IDs.

You could write a small bash script similar to this (untested):

```

trice insert -cache # Insert the IDs into the source code.
git restore til.json # Forget the todays garbage.

# Add the todays IDs to the restored til.json and clean the code.
# We have to deactivate the cache to force the file processing to get the new IDs into til.json.
trice clean # Remove the IDs from the source code with deactivated cache.

```

25.2. Long Time Availability

- You could place a download link for the Trice tool and the used **til.json** list.
- Optionally add the (compressed/encrypted) ID reference list as resource into the target FLASH memory to be sure not to loose it in the next 200 years.

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26. The Trice Insert Algorithm

26.1. Starting Conditions

@@ To understand this chapter you should look into the Trice tool source code. @@

- Before **trice i** is executed on a source tree, the starting conditions are partially undefined:
 - A trice ID list file **til.json** file must exist, but it is allowed to be empty.
 - The **til.json** is a serialized key-value map, where
 - the keys are the IDs i and
 - the values are Trice format string structs (bit width plus format string) named f.
 - When de-serializing, it is not impossible, that an ID is used more than one times. This can only happen, when **til.json** was edited manually, what normally is not done. But could be the result of a **git merge**.
 - The trice tool will report that as error and stop. The user then has to correct the error manually, for example by deleting one of the doubled keys.
 - This ID look-up is the key-value map **idToFmt TriceIDLookUp** as **map[TriceID]TriceFmt**.
 - Each ID i as key, points to one and only one f.
 - The TriceFmt structs contains the parameter width and the format string.
 - The **idToFmt** is reverted then into **fmtToId triceFmtLookUp** as **map[TriceFmt]TriceIDs**.
 - **TriceIDs** is a triceID slice because the identical f can have several ids (no shared IDs).
 - The format struct f look-up map **fmtTold** is used internally for faster access and always in sync with **idToFmt**.
 - **idToFmt** and **fmtTold** together are named lu.
 - A location information file **li.json** may exist or not.
 - The **li.json** is a serialized key-value map **idToLocRef TriceIDLookUpLI**, a **map[TriceID]TriceLI**, where
 - the keys are the IDs i and
 - the values are the location information (filename, line and position in line) structs.
 - Each ID as key points to one and only one location information.
- The **til.json** IDs may occur in the source tree not at all, once or several times. Also it is not guaranteed, that the source tree Trices match the **til.json** value.
 - That is possible after code edit, for example or code copied or modified.
 - One and only one position is used and relevant, all others are ignored. If no **til.json** exists on the expected location the user must provide one, at least an empty file.
- The **li.json** IDs may occur in the source tree not at all, once or several times. Also it is not guaranteed, that the source tree Trices match the **li.json** value.
 - One and only one position is used and relevant, all others are ignored. If no **li.json** exists on the expected location trice insert creates one there.
- The src tree can contain IDs not present inside **til.json**. This state is seldom, for example after adding sources containing IDs.

26.2. Aims

- The **trice insert** main aim is to have a consistent state between **til.json**, **li.json** and the source tree with no **ID** used twice.
- Also the changes should be minimal.
- As a general rule lu is only extendable.
- li is rebuild from scratch.
- For faster operation files will be processed parallel.

- To keep the [Trice ID management](#) simple, the `insert` operation acts "per file". That means, that in case a file is renamed or code containing trice statements is copied to an other file, new IDs are generated for the affected trices.
 - File name changes occur are not that often, so that should be acceptable.

26.3. Method

26.3.1. Trice Insert Initialization

```
// insertIDsData holds the insert run specific data.
type insertIDsData struct {
    idToFmt TriceIDLookUp // idToFmt is a trice ID lookup map and is generated from existing
til.json file at the begin of SubCmdIdInsert. This map is only extended during SubCmdIdInsert and goes
back into til.json afterwards.
    fmtToId triceFmtLookUp // fmtToId is a trice fmt lookup map (reversed idToFmt for faster
operation) and kept in sync with idToFmt. Each fmt can have several trice IDs (slice).
    idToLocRef TriceIDLookUpLI // idToLocInf is the trice ID location information as reference
generated from li.json (if exists) at the begin of SubCmdIdInsert and is not modified at all. At the
end of SubCmdIdInsert a new li.json is generated from itemToId.
    itemToId TriceItemLookUpID // itemToId is a trice item lookup ID map, extended from source tree
during SubCmdIdInsert after each found and maybe modified trice item.
    idToItem TriceIDLookupItem // idToItem is a trice ID lookup item map (reversed itemToId for
faster operation) and kept in sync with itemToId.
}
```

- Create an `insertIDsData` instance.
- De-serialize `til.json` into `idToFmt` and `fmtToId`. On error abort and report for manual correction. One result is a slice with used IDs.
- De-serialize `li.json` into `idToLocRef`. On error abort and report for manual correction. As result the slice with used IDs is extended.
 - If `li.json` contains IDs not already inside `til.json`, these are reported as warning.
 - `idToLocRef` stays untouched and is used only in cases when identical f are found.
- Create a slice `IDSpace` with numbers IDMin ... IDMax (1 ... 16383, or 1000 ... 1999 if specified in the command line that way)
- Remove all used IDs from `IDSpace`.
 - If used IDs outside IDMin and IDmax, for example IDMin=1000, IDmax=1999 and some used IDs are bigger or smaller these are not removable from IDroom what is ok.
- Create empty `itemToId` and `idToItem`.
- Walk the src and create a `source tree map` STM with
 - key=`Trice+LI` and
 - value=`ID`.
- During STM creation use these rules:
 - If the next found f src ID == n != 0:
 - If ID n already inside STM set ID = 0 (that is brutal but ok)
 - Otherwise extend STM with ID n and remove n from ID space
 - It is possible, f is used n times with different IDs, so that is no problem.
 - It is possible, f is used n times with the same ID, so the first occurrence is the winner.
 - If the next found f src ID == 0 (normal case after trice z):
 - Look in flu
 - If not there, create new id and extend STM.
 - The new ID is "new", so forbidden to be inside liu.
 - If it is accidentally somewhere in the so far unparsed src, we do not know that and therefore do not care about.
 - That is a seldom case and not worth to parse the source tree twice all the time.
 - Patch id into source and extend STM.
 - If the ID slice has len 1 (usually the case), take that n, extend STM and remove f from flu.
 - That is important because f could be copied before.
 - If the ID slice has a len > 1 (several IDs on the same string) check li
 - If li is empty, just remove the first id from the slice and extend STM
 - Loop over slice IDs
 - If a file matches, take the first occurrence, extend STM and remove id from the ID slice
 - If no file matches do the same as when li is empty.
 - That means, after file renaming or code copying between files during trice z state, new IDs are generated for that parts.
 - That is only for same f with several IDs cases
 - File changes during trice i state are ok, because STM is generated with the IDs inside the sources.

Until here the algorithm seem to be ok.

- STM is not needed but maybe helpful during debugging.
- STM than is usable to regenerate li.json and to extend til.json
- If after `trice i` a `trice c` and a `trice i` again is executed, all IDs are expected to be at the same place again. If in between `trice i`, an optional `trice c` and a `trice i` src was edited, most IDs are expected to be at the same place again.

26.4. User Code Patching (trice insert)

- A Trice **ID** is inserted by `trice insert` as shown in the table:

Unpatched User Code	After <code>trice insert</code>	Remark
<code>trice("Hi!\n");</code>	<code>trice(iD(12345), "Hi!\n");</code>	no stamps
<code>Trice("Hi!\n");</code>	<code>Trice(iD(12345), "Hi!\n");</code>	16-bit stamps
<code>TRice("Hi!\n");</code>	<code>TRice(iD(12345), "Hi!\n");</code>	32-bit stamps

- Legacy code is handled this way:

Unpatched User Code	After <code>trice insert</code>	Remark
<code>TRICE("Hi!\n");</code>	<code>TRICE(id(12345), "Hi!\n");</code>	no stamps after <code>trice i -defaultStampSize 0</code>
<code>TRICE("Hi!\n");</code>	<code>TRICE(Id(12345), "Hi!\n");</code>	16-bit stamps after <code>trice i -defaultStampSize 16</code>
<code>TRICE("Hi!\n");</code>	<code>TRICE(ID(12345), "Hi!\n");</code>	32-bit stamps after <code>trice i -defaultStampSize 32</code>
<code>TRICE(id(0), "Hi!\n");</code>	<code>TRICE(id(12345), "Hi!\n");</code>	no stamps
<code>TRICE(Id(0), "Hi!\n");</code>	<code>TRICE(Id(12345), "Hi!\n");</code>	16-bit stamps
<code>TRICE(ID(0), "Hi!\n");</code>	<code>TRICE(ID(12345), "Hi!\n");</code>	32-bit stamps

- A pre-build step `trice insert` generates the `Id(12345)` part. Examples:

- `trice i` in your project root expects a `til.json` file there and checks sources and `til.json` for changes to insert.
- `trice i -v -i ../../../.til.json -src ./src -src ./lib/src -src ./` is a typical case as automated pre-build step in your project settings telling Trice to scan the project dir and two external directories. Even `trice i` is fast, it is generally quicker to search only relevant places.

26.5. User Code Patching Examples

- A Trice **ID** is modified as shown in these cases:

- Previously inserted (patched) user code copied to a different location:

```
trice(iD(12345), "Hi!\n"); // copied
trice(iD(12345), "Hi!\n"); // original
trice(iD(12345), "Hi!\n"); // copied
```

- After updating (patching) again:

```
trice(iD(12345), "Hi!\n");
trice(iD( 1233), "Hi!\n"); // re-patched
trice(iD( 1234), "Hi!\n"); // re-patched
```

- If the code is copied inside the same file, the first occurrence after the copy stays unchanged and the following are modified.
- If the code is copied to other files only, the copies get new IDs.

- Previously inserted (patched) user code copied and modified:

```
trice(iD(12345), "Ha!\n"); // copied and modified
trice(iD(12345), "Hi!\n"); // original
trice(iD(12345), "Ha!\n"); // copied and modified
```

- o After updating (patching) again:

```
trice(iD( 2333), "Ha!\n"); // re-patched
trice(iD(12345), "Hi!\n"); // unchanged
trice(iD( 1234), "Ha!\n"); // re-patched
```

- o If the code is copied to other files, it is re-patched.

- A Trice ID is stays the same if the stamp size is changed. Example:

```
trice( iD(12345), "Hi!" ); // original
```

```
TRice( iD(12345), "Hi!" ); // manually changed stamp size and then "trice i" performed.
```

26.6. User Code Un-Patching

26.7. ID Usage Options

- Per default the `trice insert` command chooses randomly a so far unused ID for new format strings and extends `til.json`.
- After `trice c` all src IDs are removed or 0. In this state the src should go into the version management system.

26.8. General ID Management Information

- Each format string gets its unique trice ID. If the same format string is used on different source code locations it gets different trice IDs this way allowing a reliable location information.
- The trice ID-instead-of-String idea lives from pre-compile patching of the user code.
- The user has full control how to deal with that.
- There are the 3 following options and the user has to decide which fits best for him. The **Trice Cache** is probably the best fitting setup for many users.

26.8.1. Option Cleaning in a Post-build process

- The code is visually free of IDs all the time.

26.8.2. Option Let the inserted Trice ID be a Part of the User Code

- This is the legacy method. It allows unchanged src translation into code without using the trice tool.
- It is very robust and maybe needed in nasty debugging situations.
- It allows to reconstruct lost `til.json` information.
- Recommended for small projects.

26.8.3. Option Cleaning on Repository Check-In

- The code is visually free of IDs only inside the repository.

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27. Trice Speed

A Trice macro execution can be as cheap like **3 Assembler instructions or 6 processor clocks**:

<pre> 83: 0x080008BE 61CD STR r5,[r1,#0x1C] 0x080008C0 620C STR r4,[r1,#0x20] 0x080008C2 6985 LDR r5,[r0,#0x18] 84: 0x080008C4 624D STR r5,[r1,#0x24] 0x080008C6 628C STR r4,[r1,#0x28] 0x080008C8 6985 LDR r5,[r0,#0x18] 85: 0x080008CA 62CD STR r5,[r1,#0x2C] 0x080008CC 630C STR r4,[r1,#0x30] 0x080008CE 6985 LDR r5,[r0,#0x18] </pre>	<pre> TRICE(Id(59696), "msg:MEASURE execution\n"); TRICE(Id(59696), "msg:MEASURE execution\n"); TRICE(Id(59696), "msg:MEASURE execution\n"); </pre>
--	---

• Disassembly:

- Measurement: The blue SYSTICK clock counts backwards 6 clocks for each Trice macro (on an ARM M0+), what is less than 100 ns @64

Nov 29 22:28:09.635560	COM7:	15815	MEASURE execution
Nov 29 22:28:09.635560	COM7:	15809	MEASURE execution
MHz MCU clock: Nov 29 22:28:09.635560	COM7:	15803	MEASURE execution

A more realistic (typical) timing with target location and μ s timestamps, critical section and parameters is shown here with the STM32F030 M0 core:

```

Jan 2 15:10:52.495068 COM6: triceCheck.c: 746 50000030 TRICE64 double -518.054749 (%F), aDouble(y)
Jan 2 15:10:52.495068 COM6: triceCheck.c: 747 50000032 TRICE64 double -518.0547492508867 (%G), aDouble(y)
Jan 2 15:10:52.495068 COM6: triceCheck.c: 749 50000035 Formatted float & double
Jan 2 15:10:52.495068 COM6: triceCheck.c: 750 50000037 TRICE32 float 1.089608e+03 (%12.6e)
Jan 2 15:10:52.495068 COM6: triceCheck.c: 751 50000039 TRICE32 float 1089.608276 (%12.6F)
Jan 2 15:10:52.495571 COM6: triceCheck.c: 752 50000041 TRICE32 float 1089.61 (%12.6g)
Jan 2 15:10:52.495614 COM6: triceCheck.c: 753 50000043 TRICE32 float 1.089608E+03 (%12.6E)
Jan 2 15:10:52.495614 COM6: triceCheck.c: 754 50000045 TRICE32 float 1089.608276 (%12.6F)
Jan 2 15:10:52.495614 COM6: triceCheck.c: 755 50000046 TRICE32 float 1089.61 (%12.6G)
Jan 2 15:10:52.495614 COM6: triceCheck.c: 757 50000049 TRICE64 double 5.180547e+02 (%12.6e), aDouble(y)
Jan 2 15:10:52.495614 COM6: triceCheck.c: 758 50000051 TRICE64 double 518.054749 (%12.6F), aDouble(y)
Jan 2 15:10:52.495614 COM6: triceCheck.c: 759 50000053 TRICE64 double 518.055 (%12.6g), aDouble(y)
Jan 2 15:10:52.495614 COM6: triceCheck.c: 760 50000055 TRICE64 double 5.180547E+02 (%12.6E), aDouble(y)
Jan 2 15:10:52.495614 COM6: triceCheck.c: 761 50000057 TRICE64 double 518.054749 (%12.6F), aDouble(y)
Jan 2 15:10:52.495614 COM6: triceCheck.c: 762 50000060 TRICE64 double 518.055 (%12.6G), aDouble(y)
Jan 2 15:10:52.495614 COM6: main.c: 158 50000062 MSG: STOP select = 24, TriceDepthMax =1832
Jan 2 15:10:52.496122 COM6: main.c: 165 50000065 50000064  $\mu$ s - ReadUs() lasts 45 ticks
Jan 2 15:10:52.718370 COM6: main.c: 156 50200005 MSG: START select = 0, TriceDepthMax =1832
Jan 2 15:10:52.718370 COM6: triceCheck.c: 34 50200008 Various single arguments
Jan 2 15:10:52.718370 COM6: triceCheck.c: 35 50200010 TRICE8 line false (%t ,0)
Jan 2 15:10:52.718872 COM6: triceCheck.c: 36 50200012 TRICE8 line true (%t ,2)
Jan 2 15:10:52.718917 COM6: triceCheck.c: 37 50200014 TRICE8 line 255 (%u ,-1)
Jan 2 15:10:52.718917 COM6: triceCheck.c: 38 50200016 TRICE8 line 11111111 (%b ,-1)
Jan 2 15:10:52.718917 COM6: triceCheck.c: 39 50200018 TRICE8 line 377 (%o ,-1)
Jan 2 15:10:52.718917 COM6: triceCheck.c: 40 50200020 TRICE8 line 0o377 (%o ,-1)
Jan 2 15:10:52.718917 COM6: triceCheck.c: 41 50200022 TRICE8 line FF (%x ,-1)
Jan 2 15:10:52.718917 COM6: triceCheck.c: 42 50200024 TRICE8 line ff (%x ,-1)
Jan 2 15:10:52.718917 COM6: triceCheck.c: 43 50200026 TRICE8 line -1 (%d ,-1)
Jan 2 15:10:52.718917 COM6: triceCheck.c: 44 50200028 TRICE16_1 line false (%t ,0)
Jan 2 15:10:52.718917 COM6: triceCheck.c: 45 50200030 TRICE16_1 line true (%t ,2)
Jan 2 15:10:52.718917 COM6: triceCheck.c: 46 50200032 TRICE16_1 line 65535 (%u -1)
Jan 2 15:10:52.719420 COM6: triceCheck.c: 47 50200034 TRICE16_1 line 111111111111111111 (%b -1)
Jan 2 15:10:52.719459 COM6: triceCheck.c: 48 50200036 TRICE16_1 line 177777 (%o -1)

```

The MCU is clocked with 48 MHz and a Trice duration is about 2 μ s, where alone the internal ReadUs() call is already nearly 1 μ s long:

```

///! ReadUs32 reads the 1us tick in the assumption of an 48MHz systick clock using the microSecond variable and current systick value.
///! ATTENTION: This is a quick and dirty implementation working well only if this function is called in intervals smaller than 1 ms.
///! :-( Because the STM32F030 has no 32-bit sysclock counter we need to compute this value or concatenate two 16-bit timers. )
///! I see no way to find out if the systick ISR was already active shortly after a systick counter wrap, despite calling this
///! function in intervals smaller than 1 ms if not using hardware timers. To make it clear: You can use ReadUs32 to measure long
///! intervals up to over 1 hour (4294 seconds), but the "OS" needs to call ReadUs32 internally regularly in <1ms intervals.
///! \retval us count since last reset modulo 2^32
uint32_t ReadUs32( void ){
    static uint32_t us_1 = 0; // result of last call
    uint32_t us = ((uint32_t)microSecond) + (((SysTick->LOAD - SysTick->VAL) * 87381) >> 22); // Divide clock by 48,0001831 to get us.
    if( us < us_1){ // Possible very close to systick ISR, when millisecond was not incremented yet, but the systic wrapped already.
        us += 1000; // Time cannot go backwards, so correct the 1ms error in the assumption last call is not longer than 1ms back.
    }
    us_1 = us; // keep result for next call
    return us;
}

```

27.1. Target Implementation Options

All trice macros use internally this sub-macro:

```
#define TRICE_PUT(x) do{ *TriceBufferWritePosition++ = TRICE_HTOTL(x); }while(0); //! PUT copies a 32 bit x into the TRICE buffer.
```

The usual case is `#define TRICE_HTOTL(x) (x)`. The `uint32_t* TriceBufferWritePosition` points to a buffer, which is codified and used with the Trice framing sub-macros `TRICE_ENTER` and `TRICE_LEAVE` in dependence of the use case.

27.1.1. Trice Use Cases TRICE_STATIC_BUFFER and TRICE_STACK_BUFFER - direct mode only

- Each singe Trice is build inside a common buffer and finally copied inside the sub-macro `TRICE_LEAVE`.
- Disabled relevant interrupts between `TRICE_ENTER` and `TRICE_LEAVE` are mantadory for `TRICE_STATIC_BUFFER`.
- Usable for multiple non-blocking physical Trice channels but **not** recommended for some time blocking channels.
- A copy call is executed inside `TRICE_LEAVE`.

- With appropriate mapping a direct write to physical output(s) is possible:
 - RTT0 without extra copy.
 - With `TRICE_DIRECT_SEGGER_RTT_32BIT_WRITE` about 100 MCU clocks do the whole work, what is within 1.5 us @ 64 MHz.
 - AUX without extra copy.
 - Not (yet) supported UART transfer loop with polling. With 1MBit baud rate, 4-12 bytes would last 40-120 µs.

27.1.2. Trice Use Case TRICE_DOUBLE_BUFFER - deferred mode, fastest Trice execution, more RAM needed

- Several *trices* are build in a half buffer.
- No stack used.
- Disabled interrupts between `TRICE_ENTER` and `TRICE_LEAVE`.
- Usable for multiple blocking and non-blocking physical Trice channels.
- No copy call inside `TRICE_LEAVE` but optionally an additional direct mode is supported.

27.1.3. Trice Use Case TRICE_RING_BUFFER - deferred mode, balanced Trice execution time and needed RAM

- Each single *trices* is build in a ring buffer segment.
- No stack used.
- Disabled interrupts between `TRICE_ENTER` and `TRICE_LEAVE`.
- Usable for multiple blocking and non-blocking physical Trice channels.
- No copy call inside `TRICE_LEAVE` but optionally an additional direct mode is supported.
- Allocation call inside `TRICE_ENTER`

27.2. A configuration for maximum Trice execution speed with the L432_inst example

- To not loose any clocks, the function `SomeExampleTrices` in `triceExamples.c` uses the upper case macro `TRICE` for the first "Speedy Gonzales" Trices.
- The `triceConfig.h` settings are

```
#define TriceStamp16 (*DWT_CYCCNT) // @64MHz wraps after a bit more than 1ms (MCU clocks)
#define TriceStamp32 (*DWT_CYCCNT) // @64MHz -> 1 µs, wraps after 2^32 µs ~ 1.2 hours

#define TRICE_DEFERRED_UARTA 1
#define TRICE_UARTA USART2

#define TRICE_DEFERRED_OUTPUT 1
#define TRICE_BUFFER TRICE_DOUBLE_BUFFER

#define TRICE_PROTECT 0
#define TRICE_DIAGNOSTICS 0
#define TRICE_CYCLE_COUNTER 0
```

- Both time stamps use the debug watchdog counter running with the 64 MHz MCU clock.
- No direct output to not loose time during the Trice macro execution.
- Critical sections are disabled (default), so be careful where Trices are used.
- The Trice double buffer allows the Trice macros to write without checks.
- The Trice protection, diagnostics and cycle counter are disabled to not perform unneeded clocks.
- Additionally in file `flags.mak` the optimization is set to `CFLAGS += -Ofast`.

After running `./build.sh`, executing `arm-none-eabi-objdump.exe -D -S -l out clang/triceExamples.o` shows:

```
out clang/triceExamples.o:      file format elf32-littlearm

Disassembly of section .text.TriceHeadLine:
00000000 <TriceHeadLine>:
TriceHeadLine():
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst\...\exampleData\triceExamples.c:10
#include "trice.h"

//! TriceHeadLine emits a decorated name. The name length should be 18 characters.
```

```
void TriceHeadLine(char* name) {
    //! This is usable as the very first trice sequence after restart. Adapt it. Use a UTF-8 capable
editor like VS-Code or use pure ASCII.
    TriceS("w: Hello! 🙌😊\n\n" + " " * 20 + "\n\n", name);
    %s\n\n", name);
0: f240 0100 movw r1, #0
4: 4602      mov r2, r0
6: f2c0 0100 movt r1, #0
a: f643 70f1 movw r0, #16369 @ 0x3ff1
e: f7ff bffe b.w 0 <TriceS>
```

Disassembly of section .ARM.exidx.text.TriceHeadLine:

```
00000000 <.ARM.exidx.text.TriceHeadLine>:
0: 00000000 andeq r0, r0, r0
4: 00000001 andeq r0, r0, r1
```

Disassembly of section .text.SomeExampleTrices:

```
00000000 <SomeExampleTrices>:
SomeExampleTrices():
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:14
}
```

/// SomeExampleTrices generates a few Trice example logs and a burst of Trices.

```
void SomeExampleTrices(int burstCount) {
0: b5f0      push {r4, r5, r6, r7, lr}
2: af03      add r7, sp, #12
4: e92d 0700 stmdb sp!, {r8, r9, sl}
```

```
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:15
    TRICE(ID(0), "att:⌚ Speedy Gonzales A 32-bit time stamp\n");
```

```
8: f240 0100 movw r1, #0
c: f2c0 0100 movt r1, #0
10: 680d      ldr r5, [r1, #0]
12: f240 0800 movw r8, #0
16: f2c0 0800 movt r8, #0
1a: 4604      mov r4, r0
1c: 6829      ldr r1, [r5, #0]
1e: f8d8 0000 ldr.w r0, [r8]
22: f06f 0212 mvn.w r2, #18
26: 8041      strh r1, [r0, #2]
28: 0c09      lsrs r1, r1, #16
2a: 1cd3      adds r3, r2, #3
2c: 8081      strh r1, [r0, #4]
2e: 21c0      movs r1, #192 @ 0xc0
30: 8003      strh r3, [r0, #0]
32: 80c1      strh r1, [r0, #6]
```

```
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:16
    TRICE(ID(0), "att:⌚ Speedy Gonzales B 32-bit time stamp\n");
```

```
34: 682b      ldr r3, [r5, #0]
36: 1c96      adds r6, r2, #2
38: 8143      strh r3, [r0, #10]
3a: 0c1b      lsrs r3, r3, #16
3c: 8106      strh r6, [r0, #8]
3e: 8183      strh r3, [r0, #12]
40: 81c1      strh r1, [r0, #14]
```

```
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:17
    TRICE(ID(0), "att:⌚ Speedy Gonzales C 32-bit time stamp\n");
```

```
42: 682b      ldr r3, [r5, #0]
44: 1c56      adds r6, r2, #1
46: 8243      strh r3, [r0, #18]
48: 0c1b      lsrs r3, r3, #16
4a: 8206      strh r6, [r0, #16]
4c: 8283      strh r3, [r0, #20]
4e: 82c1      strh r1, [r0, #22]
```

```
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:18
    TRICE(ID(0), "att:⌚ Speedy Gonzales D 32-bit time stamp\n");
```

```
50: 682b      ldr r3, [r5, #0]
52: 8302      strh r2, [r0, #24]
54: 0c1a      lsrs r2, r3, #16
56: 8343      strh r3, [r0, #26]
```

```

58: 8382      strh    r2, [r0, #28]
5a: 83c1      strh    r1, [r0, #30]
5c: f64b 7ad4 movw    sl, #49108 @ 0xbfd4
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:19
    TRICE(Id(0), "att:@ Speedy Gonzales E 16-bit time stamp\n");
60: 682a      ldr     r2, [r5, #0]
62: f6cb 7ad4 movt    sl, #49108 @ 0xbfd4
66: f10a 1318 add.w   r3, sl, #1572888 @ 0x180018
6a: 6203      str     r3, [r0, #32]
6c: 8482      strh    r2, [r0, #36] @ 0x24
6e: 84c1      strh    r1, [r0, #38] @ 0x26
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:20
    TRICE(Id(0), "att:@ Speedy Gonzales F 16-bit time stamp\n");
70: 682a      ldr     r2, [r5, #0]
72: f10a 1317 add.w   r3, sl, #1507351 @ 0x170017
76: 6283      str     r3, [r0, #40] @ 0x28
78: 8582      strh    r2, [r0, #44] @ 0x2c
7a: 85c1      strh    r1, [r0, #46] @ 0x2e
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:21
    TRICE(Id(0), "att:@ Speedy Gonzales G 16-bit time stamp\n");
7c: 682a      ldr     r2, [r5, #0]
7e: f10a 1316 add.w   r3, sl, #1441814 @ 0x160016
82: 6303      str     r3, [r0, #48] @ 0x30
84: 8682      strh    r2, [r0, #52] @ 0x34
86: 86c1      strh    r1, [r0, #54] @ 0x36
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:22
    TRICE(Id(0), "att:@ Speedy Gonzales H 16-bit time stamp\n");
88: 682a      ldr     r2, [r5, #0]
8a: f10a 1315 add.w   r3, sl, #1376277 @ 0x150015
8e: 8782      strh    r2, [r0, #60] @ 0x3c
90: f647 72e8 movw    r2, #32744 @ 0x7fe8
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:23
    TRICE(id(0), "att:@ Speedy Gonzales I without time stamp\n");
94: f8a0 2040 strh.w  r2, [r0, #64] @ 0x40
98: f647 72e7 movw    r2, #32743 @ 0x7fe7
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:24
    TRICE(id(0), "att:@ Speedy Gonzales J without time stamp\n");
9c: f8a0 2044 strh.w  r2, [r0, #68] @ 0x44
a0: f647 72e6 movw    r2, #32742 @ 0x7fe6
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:25
    TRICE(id(0), "att:@ Speedy Gonzales K without time stamp\n");
a4: f8a0 2048 strh.w  r2, [r0, #72] @ 0x48
a8: f647 72e5 movw    r2, #32741 @ 0x7fe5
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:22
    TRICE(Id(0), "att:@ Speedy Gonzales H 16-bit time stamp\n");
ac: 6383      str     r3, [r0, #56] @ 0x38
ae: 87c1      strh    r1, [r0, #62] @ 0x3e
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:23
    TRICE(id(0), "att:@ Speedy Gonzales I without time stamp\n");
b0: f8a0 1042 strh.w  r1, [r0, #66] @ 0x42
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:24
    TRICE(id(0), "att:@ Speedy Gonzales J without time stamp\n");
b4: f8a0 1046 strh.w  r1, [r0, #70] @ 0x46
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:25
    TRICE(id(0), "att:@ Speedy Gonzales K without time stamp\n");
b8: f8a0 104a strh.w  r1, [r0, #74] @ 0x4a
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../exampleData/triceExamples.c:26
    TRICE(id(0), "att:@ Speedy Gonzales L without time stamp\n");
bc: f8a0 204c strh.w  r2, [r0, #76] @ 0x4c
c0: f8a0 104e strh.w  r1, [r0, #78] @ 0x4e
TRice0():
C:\Users\ms\repos\trice_wt-devel\examples\L432_inst/../../../src/trice.h:741
    Trice32m_0(tid);
    TRICE_UNUSED(pFmt)
}
...

```

- There are only 7 assembler instructions between two `TRICE` macros(around line 17).
- The log output is:

```
ms@DESKTOP-7POEGPB MINGW64 ~/repos/trice_wt-devel/examples/L432_inst (devel)
$ trice log -p com8 -showID "d:%5d"
Dec 5 14:56:01.595696 com8: triceExamples.c 10 0.279 16369 Hello! .o.o
Dec 5 14:56:01.595696 com8: * * * * *
Dec 5 14:56:01.595696 com8: * * * * * nuced-L432KC * * * *
Dec 5 14:56:01.595696 com8: * * * * *
Dec 5 14:56:01.595696 com8: * * * * *
Dec 5 14:56:01.595696 com8: triceconfig.h 45 16196 CONFIGURATION == 0 - An example configuration
Dec 5 14:56:01.595696 com8: triceExamples.c 59 16334 TRICE_DIRECT_OUTPUT == 0, TRICE_DEFERRED_OUTPUT == 1
Dec 5 14:56:01.595696 com8: triceExamples.c 65 16331 TRICE_DOUBLE_BUFFER, TRICE_MULTI_PACK_MODE
Dec 5 14:56:01.596358 com8: triceExamples.c 74 16327 _CYCLE == 0, _PROTECT == 0, _DIAG == 0, XTEA == 0
Dec 5 14:56:01.596864 com8: triceExamples.c 75 16326 SINGLE_MAX_SIZE=104, BUFFER_SIZE=172, DEFERRED_BUFFER_SIZE=4096
Dec 5 14:56:01.596864 com8: triceExamples.c 15 0.003_31 16368 Speedy Gonzales A 32-bit time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 16 0.003_33 16367 Speedy Gonzales B 32-bit time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 17 0.003_34 16366 Speedy Gonzales C 32-bit time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 18 0.003_35 16365 Speedy Gonzales D 32-bit time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 19 3.361 16364 Speedy Gonzales E 16-bit time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 20 3.373 16363 Speedy Gonzales F 16-bit time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 21 3.379 16362 Speedy Gonzales G 16-bit time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 22 3.387 16361 Speedy Gonzales H 16-bit time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 23 16360 Speedy Gonzales I without time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 24 16359 Speedy Gonzales J without time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 25 16358 Speedy Gonzales K without time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 26 16357 Speedy Gonzales L without time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 27 0.003_424 16356 Speedy Gonzales a 32-bit time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 28 0.003_437 16355 Speedy Gonzales b 32-bit time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 29 0.003_450 16354 Speedy Gonzales c 32-bit time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 30 0.003_461 16353 Speedy Gonzales d 32-bit time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 31 3.476 16352 Speedy Gonzales e 16-bit time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 32 3.486 16351 Speedy Gonzales f 16-bit time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 33 3.494 16350 Speedy Gonzales g 16-bit time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 34 3.506 16349 Speedy Gonzales h 16-bit time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 35 16348 Speedy Gonzales i without time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 36 16347 Speedy Gonzales j without time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 37 16346 Speedy Gonzales k without time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 38 16345 Speedy Gonzales l without time stamp
Dec 5 14:56:01.596864 com8: triceExamples.c 40 3.753 16344 2.71828182845904523536 <- float number as string
Dec 5 14:56:01.597391 com8: triceExamples.c 41 4.066 16343 2.71828182845904509080 (double with more ciphers than precision)
Dec 5 14:56:01.597391 com8: triceExamples.c 42 4.123 16342 2.71828174591064453125 (float with more ciphers than precision)
Dec 5 14:56:01.597391 com8: triceExamples.c 43 4.164 16341 2.718282 (default rounded float)
Dec 5 14:56:01.597391 com8: triceExamples.c 44 4.178 16340 A Buffer:
Dec 5 14:56:01.597391 com8: triceExamples.c 45 4.236 16339 32 2e 37 31 38 32 38 31 38 32 38 34 35 39 30 34 35 32 33 35 33 36
Dec 5 14:56:01.597391 com8: triceExamples.c 46 4.520 16338 31372e32 31383238 34383238 34303935 35333235
Dec 5 14:56:01.597391 com8: triceExamples.c 47 4.74 16337 AREmoteFunctionName(2e32)(3137)(3238)(3138)(3238)(3438)(3935)(3430)(3235)(3533)(3633)
```

As you can see in the highlighted blue timestamp bar, typical 8-10 clocks are needed for one Trice macro. One clock duration @64MHz is 15.625 ns, so we need about 150 ns for a Trice. Light can travel about 50 meter in that time.

27.3. A configuration for normal Trice execution speed with the G0B1_inst example

- The `triceConfig.h` settings are

```
// hardware specific trice lib settings
#include "main.h"
#define TriceStamp16 TIM17->CNT      // 0...999 us
#define TriceStamp32 HAL_GetTick()    // 0...2^32-1 ms (wraps after 49.7 days)

#define TRICE_BUFFER TRICE_RING_BUFFER

// trice l -p JLINK -args="--Device STM32G0B1RE -if SWD -Speed 4000 -RTTChannel 0" -pf none -d16 -ts
ms
// #define TRICE_DIRECT_OUTPUT 1
// #define TRICE_DIRECT_SEGGER_RTT_32BIT_WRITE 1

// trice log -p com7 -pw MySecret -pf COBS
#define TRICE_DEFERRED_OUTPUT 1
#define TRICE_DEFERRED_XTEA_ENCRYPT 1
#define TRICE_DEFERRED_OUT_FRAMING TRICE_FRAMING_COBS
#define TRICE_DEFERRED_UARTA 1
#define TRICE_UARTA USART2

#include "cmsis_gcc.h"
#define TRICE_ENTER_CRITICAL_SECTION { uint32_t primaskstate = __get_PRIMASK(); __disable_irq(); }
#define TRICE_LEAVE_CRITICAL_SECTION } __set_PRIMASK(primaskstate); }
```

- The 16-bit time stamp counts the microseconds within 1 millisecond.
- The 32-bit time stamp counts the milliseconds.
- The ring buffer uses the RAM more effectively for the price of a bit speed.
- The encryption and framing has no influence on the Trice execution speed because this is done in the background.
- The critical section protects Trices in different tasks from each-other interruption and allows Trices inside interrupts parallel to normal usage.
- Per default are Trice protection, diagnostics and cycle counter active.

```

trice l -p com6 -pw MySecret -pf cobs
Dec 5 17:44:20.687355 com6: triceExamples.c 10 0_000 Hello! @
Dec 5 17:44:20.687355 com6: * * * * *
Dec 5 17:44:20.687355 com6: @ @ @ NUCLEO-GOB1RE @ @ @
Dec 5 17:44:20.687355 com6: @ @ @ @ @ @ @ @ @ @ @ @ @ @
Dec 5 17:44:20.687355 com6:
Dec 5 17:44:20.687355 com6: triceExamples.c 59 [REDACTED] TRICE_DIRECT_OUTPUT == 0, TRICE_DEFERRED_OUTPUT == 1
Dec 5 17:44:20.687355 com6: triceExamples.c 65 [REDACTED] TRICE_DOUBLE_BUFFER, TRICE_MULTI_PACK_MODE
Dec 5 17:44:20.687909 com6: triceExamples.c 74 [REDACTED] _CYCLE == 1, _PROTECT == 1, _DIAG == 1, XTEA == 1
Dec 5 17:44:20.687909 com6: triceExamples.c 75 [REDACTED] _STRING_MAX_SIZE=104, _BUFFER_SIZE=172, _DEFERRED_BUFFER_SIZE=4096
Dec 5 17:44:20.688440 com6: triceExamples.c 15 0,000_002 ⚡ Speedy Gonzales A 32-bit time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 16 0,000_002 ⚡ Speedy Gonzales B 32-bit time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 17 0,000_002 ⚡ Speedy Gonzales C 32-bit time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 18 0,000_002 ⚡ Speedy Gonzales D 32-bit time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 19 0,149 ⚡ Speedy Gonzales E 16-bit time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 20 0,152 ⚡ Speedy Gonzales F 16-bit time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 21 0,156 ⚡ Speedy Gonzales G 16-bit time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 22 0,160 ⚡ Speedy Gonzales H 16-bit time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 23 0 [REDACTED] Speedy Gonzales I without time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 24 0 [REDACTED] Speedy Gonzales J without time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 25 0 [REDACTED] Speedy Gonzales K without time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 26 0 [REDACTED] Speedy Gonzales L without time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 27 0,000_002 ⚡ Speedy Gonzales a 32-bit time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 28 0,000_002 ⚡ Speedy Gonzales b 32-bit time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 29 0,000_002 ⚡ Speedy Gonzales c 32-bit time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 30 0,000_002 ⚡ Speedy Gonzales d 32-bit time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 31 0,196 ⚡ Speedy Gonzales e 16-bit time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 32 0,200 ⚡ Speedy Gonzales f 16-bit time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 33 0,204 ⚡ Speedy Gonzales g 16-bit time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 34 0,208 ⚡ Speedy Gonzales h 16-bit time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 35 0 [REDACTED] Speedy Gonzales i without time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 36 0 [REDACTED] Speedy Gonzales j without time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 37 0 [REDACTED] Speedy Gonzales k without time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 38 0 [REDACTED] Speedy Gonzales l without time stamp
Dec 5 17:44:20.688440 com6: triceExamples.c 40 0,236 2.7182812845904523536 <- float number as string
Dec 5 17:44:20.688440 com6: triceExamples.c 41 0,262 2.7182812845904509080 (double with more ciphers than precision)
Dec 5 17:44:20.688969 com6: triceExamples.c 42 0,268 2.71828174591064453125 (float with more ciphers than precision)
Dec 5 17:44:20.689037 com6: triceExamples.c 43 0,274 2.718282 (default rounded float)
Dec 5 17:44:20.689037 com6: triceExamples.c 44 0,279 A Buffer:
Dec 5 17:44:20.689037 com6: triceExamples.c 45 0,285 32 2e 37 31 38 32 38 31 38 32 38 34 35 39 30 34 35 32 33 35 33 36
Dec 5 17:44:20.689037 com6: triceExamples.c 46 0,311 31372e32 31383238 34383238 34303935 35333235
Dec 5 17:44:20.689037 com6: triceExamples.c 47 0,333 ARemoteFunctionName(2e32)(3137)(3238)(3138)(3238)(3438)(3935)(3430)(3235)(3533)(3633)

```

- A typical Trice duration is here 4 microseconds (with `-Ospeed`)
 - Switching the optimization to `-Oz` can result in typical 4-5 µs Trice execution time.
 - Additionally enabling the Trice direct out over Segger RTT has this impact:

```
$ trice l -p JLINK -args="--Device STM32G0B1RE -if SWD -Speed 4000 -RTTChannel 0" -pf none -d16 -ts ms
Dec 5 18:04:08.664777 JLINK:           triceExamples.c  10  0.000 Hello! ☺☺
Dec 5 18:04:08.664777 JLINK:           * * * * * * * * *
Dec 5 18:04:08.664777 JLINK:           ♀ ♀ ♀ ♀ NUCLEO-G0B1RE ♀ ♀ ♀
Dec 5 18:04:08.664777 JLINK:           ☺ ☺ ☺ ☺ ☺ ☺ ☺ ☺ ☺ ☺ ☺ ☺
Dec 5 18:04:08.664777 JLINK:           triceExamples.c  59
Dec 5 18:04:08.664777 JLINK:           triceExamples.c  65
Dec 5 18:04:08.664777 JLINK:           triceExamples.c  74
Dec 5 18:04:08.665360 JLINK:           triceExamples.c  74
Dec 5 18:04:08.665360 JLINK:           TRICE_DIRECT_OUTPUT == 1, TRICE_DEFERRED_OUTPUT == 1
Dec 5 18:04:08.665360 JLINK:           TRICE_DOUBLE_BUFFER, TRICE_MULTI_PACK_MODE
Dec 5 18:04:08.665360 JLINK:           _CYCLE == 1, _PROTECT == 1, _DIAG == 1, XTEA == 1

MINGW64:/c/Users/ms/repos/trice_wt-devel/examples/G0B1_inst

ms@DESKTOP-7POEGB MINGW64 ~/repos/trice_wt-devel/examples/G0B1_inst (devel)
$ trice l -p com6 -pw MySecret -pf cobs
Dec 5 18:04:06.533147 com6:           triceExamples.c  10  0.000 Hello! ☺☺
Dec 5 18:04:06.533147 com6:
Dec 5 18:04:06.533147 com6:           * * * * * * * * *
Dec 5 18:04:06.533147 com6:           ♀ ♀ ♀ ♀ NUCLEO-G0B1RE ♀ ♀ ♀
Dec 5 18:04:06.533147 com6:           ☺ ☺ ☺ ☺ ☺ ☺ ☺ ☺ ☺ ☺ ☺ ☺
Dec 5 18:04:06.533147 com6:
Dec 5 18:04:06.533147 com6:
Dec 5 18:04:06.533147 com6:           triceExamples.c  59
Dec 5 18:04:06.533147 com6:           triceExamples.c  65
Dec 5 18:04:06.533147 com6:           triceExamples.c  74
Dec 5 18:04:06.533779 com6:           triceExamples.c  75
Dec 5 18:04:06.533779 com6:           triceExamples.c  15  0.000_002 ☺ Speedy Gonzales A 32-bit time stamp
Dec 5 18:04:06.533779 com6:           triceExamples.c  16  0.000_002 ☺ Speedy Gonzales B 32-bit time stamp
Dec 5 18:04:06.533779 com6:           triceExamples.c  17  0.000_002 ☺ Speedy Gonzales C 32-bit time stamp
Dec 5 18:04:06.533779 com6:           triceExamples.c  18  0.000_002 ☺ Speedy Gonzales D 32-bit time stamp
Dec 5 18:04:06.533779 com6:           triceExamples.c  19  0._309 ☺ Speedy Gonzales E 16-bit time stamp
Dec 5 18:04:06.533779 com6:           triceExamples.c  20  0._330 ☺ Speedy Gonzales F 16-bit time stamp
Dec 5 18:04:06.533779 com6:           triceExamples.c  21  0._351 ☺ Speedy Gonzales G 16-bit time stamp
Dec 5 18:04:06.533779 com6:           triceExamples.c  22  0._373 ☺ Speedy Gonzales H 16-bit time stamp
Dec 5 18:04:06.533779 com6:           triceExamples.c  23
Dec 5 18:04:06.533779 com6:           triceExamples.c  24
Dec 5 18:04:06.533779 com6:           triceExamples.c  25
Dec 5 18:04:06.533779 com6:           triceExamples.c  26
Dec 5 18:04:06.533779 com6:           triceExamples.c  27  0.000_002 ☺ Speedy Gonzales a 32-bit time stamp
Dec 5 18:04:06.533779 com6:           triceExamples.c  28  0.000_002 ☺ Speedy Gonzales b 32-bit time stamp
Dec 5 18:04:06.533779 com6:           triceExamples.c  29  0.000_002 ☺ Speedy Gonzales c 32-bit time stamp
Dec 5 18:04:06.533779 com6:           triceExamples.c  30  0.000_002 ☺ Speedy Gonzales d 32-bit time stamp
Dec 5 18:04:06.533779 com6:           triceExamples.c  31  0._570 ☺ Speedy Gonzales e 16-bit time stamp
Dec 5 18:04:06.533779 com6:           triceExamples.c  32  0._593 ☺ Speedy Gonzales f 16-bit time stamp
Dec 5 18:04:06.534285 com6:           triceExamples.c  33  0._616 ☺ Speedy Gonzales g 16-bit time stamp
```

 The Trice execution time is now over 20 microseconds !

Still fast enough for many cases but you hopefully have a good knowledge now how to tune Trice best for your application.

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28. Trice memory needs

Depending on your target configuration the needed space can differ:

28.1. F030_bare Size

- `./build.sh`:

```
arm-none-eabi-size build/F030_bare.elf
text      data      bss      dec      hex filename
2428       12     1564     4004    fa4 build/F030_bare.elf
```

That is the basic size of an empty generated project just containing some drivers.

28.2. F030_inst Size with TRICE_OFF=1

- `./build.sh TRICE_OFF=1`:

```
arm-none-eabi-size build/F030_inst.elf
text      data      bss      dec      hex filename
2428       12     1564     4004    fa4 build/F030_inst.elf
```

This is exactly the same result, proofing that `TRICE_OFF 1` is working correctly.

28.3. F030_inst with ring buffer

- `./build.sh`:

```
arm-none-eabi-size out/F030_inst.elf
text      data      bss      dec      hex filename
9416       28     2692    12136    2f68 out/F030_inst.elf
```

This is about 7 KB Flash and 1.2 KB RAM size for the Trice library and we see:

```
ms@DESKTOP-7P0EGPB MINGW64 ~/repos/trice_wt-devel/examples/F030_inst (devel)
$ trice l -p com5 -ts16 "time: #%6d" -hs off
com5:      triceExamples.c 12      # 65535 Hello! 🙌😊
com5:
com5:      +-----+
com5:      🔴🔴🔴🔴  TRICE@F030R8  🔴🔴🔴🔴
com5:      🔵🔵🔵🔵 🔵🔵🔵🔵 🔵🔵🔵🔵 🔵🔵🔵🔵 🔵
com5:
com5:
com5:      triceExamples.c 61      TRICE_DIRECT_OUTPUT == 0, TRICE_DEFERRED_OUTPUT == 1
com5:      triceExamples.c 67      TRICE_DOUBLE_BUFFER, TRICE_MULTI_PACK_MODE
com5:      triceExamples.c 76      _CYCLE == 1, _PROTECT == 1, _DIAG == 1, XTEA == 0
com5:      triceExamples.c 77      _SINGLE_MAX_SIZE=104, _BUFFER_SIZE=172,
_DEFERRED_BUFFER_SIZE=1024
com5:      triceExamples.c 29      0,031_804 💡 Speedy Gonzales a 32-bit time stamp
com5:      triceExamples.c 30      0,031_646 💡 Speedy Gonzales b 32-bit time stamp
com5:      triceExamples.c 31      0,031_488 💡 Speedy Gonzales c 32-bit time stamp
com5:      triceExamples.c 32      0,031_330 💡 Speedy Gonzales d 32-bit time stamp
com5:      triceExamples.c 33      # 31172 💡 Speedy Gonzales e 16-bit time stamp
com5:      triceExamples.c 34      # 31012 💡 Speedy Gonzales f 16-bit time stamp
com5:      triceExamples.c 35      # 30852 💡 Speedy Gonzales g 16-bit time stamp
com5:      triceExamples.c 36      # 30692 💡 Speedy Gonzales h 16-bit time stamp
com5:      triceExamples.c 42      # 30224 2.71828182845904523536 <- float number as string
com5:      triceExamples.c 43      # 29517 2.71828182845904509080 (double with more ciphers than
precision)
com5:      triceExamples.c 44      # 29322 2.71828174591064453125 (float with more ciphers than
precision)
com5:      triceExamples.c 45      # 29145 2.718282 (default rounded float)
com5:      triceExamples.c 46      # 28969 A Buffer:
com5:      triceExamples.c 47      # 28790 32 2e 37 31 38 32 38 31 38 32 38 34 35 39 30 34 35 32
33 35 33 36
com5:      triceExamples.c 48      # 28076 31372e32 31383238 34383238 34303935 35333235
```

```

com5:     triceExamples.c  49      # 27430 ARemoteFunctionName(2e32)(3137)(3238)(3138)(3238)(3438)
(3935)(3430)(3235)(3533)(3633)
com5:     triceExamples.c  50      5 times a 16 byte long Trice messages, which may not be
written all if the buffer is too small:
com5:     triceExamples.c  52      # 26554 i=44444400 aaaaaaa00
com5:     triceExamples.c  52      # 26342 i=44444401 aaaaaaa01
com5:     triceExamples.c  52      # 26130 i=44444402 aaaaaaa02
com5:     triceExamples.c  52      # 25918 i=44444403 aaaaaaa03
com5:     triceExamples.c  52      # 25706 i=44444404 aaaaaaa04
com5:     triceExamples.c  29      0,031_790 🎉 Speedy Gonzales a 32-bit time stamp
com5:     triceExamples.c  30      0,031_632 🎉 Speedy Gonzales b 32-bit time stamp
com5:     triceExamples.c  31      0,031_474 🎉 Speedy Gonzales c 32-bit time stamp
com5:     triceExamples.c  32      0,031_316 🎉 Speedy Gonzales d 32-bit time stamp
com5:     triceExamples.c  33      # 31158 🎉 Speedy Gonzales e 16-bit time stamp
com5:     triceExamples.c  34      # 30998 🎉 Speedy Gonzales f 16-bit time stamp
com5:     triceExamples.c  35      # 30838 🎉 Speedy Gonzales g 16-bit time stamp
com5:     triceExamples.c  36      # 30678 🎉 Speedy Gonzales h 16-bit time stamp
com5:     triceExamples.c  42      # 30210 2.71828182845904523536 <- float number as string
com5:     triceExamples.c  43      # 29503 2.71828182845904509080 (double with more ciphers than
precision)
com5:     triceExamples.c  44      # 29308 2.71828174591064453125 (float with more ciphers than
precision)
com5:     triceExamples.c  45      # 29131 2.718282 (default rounded float)
com5:     triceExamples.c  46      # 28955 A Buffer:
com5:     triceExamples.c  47      # 28776 32 2e 37 31 38 32 38 31 38 32 38 34 35 39 30 34 35 32
33 35 33 36
com5:     triceExamples.c  48      # 28062 31372e32 31383238 34383238 34303935 35333235
com5:     triceExamples.c  49      # 27416 ARemoteFunctionName(2e32)(3137)(3238)(3138)(3238)
(3935)(3430)(3235)(3533)(3633)
com5:     triceExamples.c  50      5 times a 16 byte long Trice messages, which may not be
written all if the buffer is too small:
com5:     triceExamples.c  52      # 26540 i=44444400 aaaaaaa00
com5:     triceExamples.c  52      # 26328 i=44444401 aaaaaaa01
com5:     triceExamples.c  52      # 26116 i=44444402 aaaaaaa02
com5:     triceExamples.c  52      # 25904 i=44444403 aaaaaaa03
com5:     triceExamples.c  52      # 25692 i=44444404 aaaaaaa04
com5:     tricelogDiagData.c 44      triceSingleDepthMax = 108 of 172 (TRICE_BUFFER_SIZE)
com5:     tricelogDiagData.c 67      TriceHalfBufferDepthMax = 388 of 512
com5:     triceExamples.c  29      0,031_344 🎉 Speedy Gonzales a 32-bit time stamp
com5:     triceExamples.c  30      0,031_186 🎉 Speedy Gonzales b 32-bit time stamp

```

28.4. F030_inst with ring buffer

- ./build.sh:

We need 600 bytes more Flash but could have less RAM used:

text	data	bss	dec	hex	filename
10060	24	2688	12772	31e4	out/F030_inst.elf

```

ms@DESKTOP-7P0EGPB MINGW64 ~/repos/trice_wt-devel/examples/F030_inst (devel)
$ trice l -p com5 -ts16 "time:    %#6d" -hs off
com5:     triceExamples.c  12      # 65535 Hello! 🎉😊
com5:
com5:     🎉🎉🎉🎉🎉🎉🎉🎉🎉🎉🎉🎉
com5:     triceExamples.c  61      TRICE_DIRECT_OUTPUT == 0, TRICE_DEFERRED_OUTPUT == 1
com5:     triceExamples.c  69      TRICE_RING_BUFFER, TRICE_MULTI_PACK_MODE
com5:     triceExamples.c  76      _CYCLE == 1, _PROTECT == 1, _DIAG == 1, XTEA == 0
com5:     triceExamples.c  77      _SINGLE_MAX_SIZE=104, _BUFFER_SIZE=172,
_comDeferred_Buffer_Size=1024
com5:     triceExamples.c  29      0,031_732 🎉 Speedy Gonzales a 32-bit time stamp
com5:     triceExamples.c  30      0,031_531 🎉 Speedy Gonzales b 32-bit time stamp
com5:     triceExamples.c  31      0,031_330 🎉 Speedy Gonzales c 32-bit time stamp

```

```

com5:      triceExamples.c 32    0,031_129 ⓘ Speedy Gonzales d 32-bit time stamp
com5:      triceExamples.c 33    # 30928 ⓘ Speedy Gonzales e 16-bit time stamp
com5:      triceExamples.c 34    # 30725 ⓘ Speedy Gonzales f 16-bit time stamp
com5:      triceExamples.c 35    # 30522 ⓘ Speedy Gonzales g 16-bit time stamp
com5:      triceExamples.c 36    # 30319 ⓘ Speedy Gonzales h 16-bit time stamp
com5:      triceExamples.c 42    # 29808 2.71828182845904523536 <- float number as string
com5:      triceExamples.c 43    # 29058 2.71828182845904509080 (double with more ciphers than
precision)
com5:      triceExamples.c 44    # 28821 2.71828174591064453125 (float with more ciphers than
precision)
com5:      triceExamples.c 45    # 28602 2.718282 (default rounded float)
com5:      triceExamples.c 46    # 28383 A Buffer:
com5:      triceExamples.c 47    # 28162 32 2e 37 31 38 32 38 31 38 32 38 34 35 39 30 34 35 32
33 35 33 36
com5:      triceExamples.c 48    # 27406 31372e32 31383238 34383238 34303935 35333235
com5:      triceExamples.c 49    # 26718 ARemoteFunctionName(2e32)(3137)(3238)(3138)(3238)(3438)
(3935)(3430)(3235)(3533)(3633)
com5:      triceExamples.c 50      5 times a 16 byte long Trice messages, which may not be
written all if the buffer is too small:
com5:      triceExamples.c 52    # 25757 i=44444400 aaaaaaa0
com5:      triceExamples.c 52    # 25502 i=44444401 aaaaaaa01
com5:      triceExamples.c 52    # 25247 i=44444402 aaaaaaa02
com5:      triceExamples.c 52    # 24992 i=44444403 aaaaaaa03
com5:      triceExamples.c 52    # 24737 i=44444404 aaaaaaa04
com5:      triceExamples.c 29    0,031_746 ⓘ Speedy Gonzales a 32-bit time stamp
com5:      triceExamples.c 30    0,031_545 ⓘ Speedy Gonzales b 32-bit time stamp
com5:      triceExamples.c 31    0,031_344 ⓘ Speedy Gonzales c 32-bit time stamp
com5:      triceExamples.c 32    0,031_143 ⓘ Speedy Gonzales d 32-bit time stamp
com5:      triceExamples.c 33    # 30942 ⓘ Speedy Gonzales e 16-bit time stamp
com5:      triceExamples.c 34    # 30739 ⓘ Speedy Gonzales f 16-bit time stamp
com5:      triceExamples.c 35    # 30536 ⓘ Speedy Gonzales g 16-bit time stamp
com5:      triceExamples.c 36    # 30333 ⓘ Speedy Gonzales h 16-bit time stamp
com5:      triceExamples.c 42    # 29822 2.71828182845904523536 <- float number as string
com5:      triceExamples.c 43    # 29072 2.71828182845904509080 (double with more ciphers than
precision)
com5:      triceExamples.c 44    # 28835 2.71828174591064453125 (float with more ciphers than
precision)
com5:      triceExamples.c 45    # 28616 2.718282 (default rounded float)
com5:      triceExamples.c 46    # 28397 A Buffer:
com5:      triceExamples.c 47    # 28176 32 2e 37 31 38 32 38 31 38 32 38 34 35 39 30 34 35 32
33 35 33 36
com5:      triceExamples.c 48    # 27420 31372e32 31383238 34383238 34303935 35333235
com5:      triceExamples.c 49    # 26732 ARemoteFunctionName(2e32)(3137)(3238)(3138)(3238)(3438)
(3935)(3430)(3235)(3533)(3633)
com5:      triceExamples.c 50      5 times a 16 byte long Trice messages, which may not be
written all if the buffer is too small:
com5:      triceExamples.c 52    # 25771 i=44444400 aaaaaaa0
com5:      triceExamples.c 52    # 25516 i=44444401 aaaaaaa01
com5:      triceExamples.c 52    # 25261 i=44444402 aaaaaaa02
com5:      triceExamples.c 52    # 25006 i=44444403 aaaaaaa03
com5:      triceExamples.c 52    # 24751 i=44444404 aaaaaaa04
com5:      triceLogDiagData.c 44    triceSingleDepthMax = 108 of 172 (TRICE_BUFFER_SIZE)
com5:      triceLogDiagData.c 75    triceRingBufferDepthMax = 324 of 1024
com5:      triceExamples.c 29    0,031_188 ⓘ Speedy Gonzales a 32-bit time stamp
com5:      triceExamples.c 30    0,030_987 ⓘ Speedy Gonzales b 32-bit time stamp

```

28.5. A developer setting, only enabling SEGGER_RTT

- `./build.sh`:

```

arm-none-eabi-size out/F030_inst.elf
text      data      bss      dec      hex filename
6656       16     2768     9440    24e0 out/F030_inst.elf

```

About 4 KB Flash needed and we see:

```

ms@DESKTOP-7POEGPB MINGW64 ~/repos/trice_wt-devel/examples/F030_inst (devel)
$ trice l -p jlink -args "-Device STM32F030R8 -if SWD -Speed 4000 -RTTChannel 0" -pf none -d16 -showID
"deb:%5d"
Dec 6 16:14:38.276356 jlink:      triceExamples.c 12      65_535 16369 Hello! 🎉😊
Dec 6 16:14:38.276356 jlink:
Dec 6 16:14:38.276356 jlink:      triceExamples.c 61      16334 TRICE_DIRECT_OUTPUT ==
1, TRICE_DEFERRED_OUTPUT == 0
Dec 6 16:14:38.276356 jlink:      triceExamples.c 63      16333 TRICE_STACK_BUFFER,
TRICE_MULTI_PACK_MODE
Dec 6 16:14:38.276920 jlink:      triceExamples.c 76      16327 _CYCLE == 1, _PROTECT ==
1, _DIAG == 1, XTEA == 0
Dec 6 16:14:38.277424 jlink:      triceExamples.c 77      16326 _SINGLE_MAX_SIZE=104,
_BUFFFER_SIZE=172, _DEFERRED_BUFFFER_SIZE=1024
Dec 6 16:14:39.181228 jlink:      triceExamples.c 29      0,031_848 16356 🚗 Speedy Gonzales a
32-bit time stamp
Dec 6 16:14:39.181228 jlink:      triceExamples.c 30      0,031_292 16355 🚗 Speedy Gonzales b
32-bit time stamp
Dec 6 16:14:39.181228 jlink:      triceExamples.c 31      0,030_736 16354 🚗 Speedy Gonzales c
32-bit time stamp
Dec 6 16:14:39.181228 jlink:      triceExamples.c 32      0,030_180 16353 🚗 Speedy Gonzales d
32-bit time stamp
Dec 6 16:14:39.181228 jlink:      triceExamples.c 33      29_624 16352 🚗 Speedy Gonzales e
16-bit time stamp
Dec 6 16:14:39.181228 jlink:      triceExamples.c 34      29_066 16351 🚗 Speedy Gonzales f
16-bit time stamp
Dec 6 16:14:39.181228 jlink:      triceExamples.c 35      28_508 16350 🚗 Speedy Gonzales g
16-bit time stamp
Dec 6 16:14:39.181228 jlink:      triceExamples.c 36      27_950 16349 🚗 Speedy Gonzales h
16-bit time stamp
Dec 6 16:14:39.181228 jlink:      triceExamples.c 42      27_086 16344 2.71828182845904523536
<- float number as string
Dec 6 16:14:39.181228 jlink:      triceExamples.c 43      25_906 16343 2.71828182845904509080
(double with more ciphers than precision)
Dec 6 16:14:39.181798 jlink:      triceExamples.c 44      25_305 16342 2.71828174591064453125
(float with more ciphers than precision)
Dec 6 16:14:39.181798 jlink:      triceExamples.c 45      24_727 16341 2.718282 (default
rounded float)
Dec 6 16:14:39.181798 jlink:      triceExamples.c 46      24_148 16340 A Buffer:
Dec 6 16:14:39.181798 jlink:      triceExamples.c 47      23_578 16339 32 2e 37 31 38 32 38 31
38 32 38 34 35 39 30 34 35 32 33 35 33 36
Dec 6 16:14:39.181798 jlink:      triceExamples.c 48      22_394 16338 31372e32 31383238
34383238 34303935 35333235
Dec 6 16:14:39.181798 jlink:      triceExamples.c 49      21_295 16337
ARemoteFunctionName(2e32)(3137)(3238)(3138)(3238)(3438)(3935)(3430)(3235)(3533)(3633)
Dec 6 16:14:39.181798 jlink:      triceExamples.c 50      16200 5 times a 16 byte long
Trice messages, which may not be written all if the buffer is too small:
Dec 6 16:14:39.182303 jlink:      triceExamples.c 52      19_555 16335 i=44444400 aaaaaa00
Dec 6 16:14:39.182303 jlink:      triceExamples.c 52      18_941 16335 i=44444401 aaaaaa01
Dec 6 16:14:39.182303 jlink:      triceExamples.c 52      18_327 16335 i=44444402 aaaaaa02
Dec 6 16:14:39.182834 jlink:      triceExamples.c 52      17_713 16335 i=44444403 aaaaaa03
Dec 6 16:14:39.182834 jlink:      triceExamples.c 52      17_099 16335 i=44444404 aaaaaa04
Dec 6 16:14:40.187121 jlink:      triceExamples.c 29      0,031_855 16356 🚗 Speedy Gonzales a
32-bit time stamp
Dec 6 16:14:40.187121 jlink:      triceExamples.c 30      0,031_299 16355 🚗 Speedy Gonzales b
32-bit time stamp
Dec 6 16:14:40.187121 jlink:      triceExamples.c 31      0,030_743 16354 🚗 Speedy Gonzales c
32-bit time stamp
Dec 6 16:14:40.187121 jlink:      triceExamples.c 32      0,030_187 16353 🚗 Speedy Gonzales d
32-bit time stamp
Dec 6 16:14:40.187121 jlink:      triceExamples.c 33      29_631 16352 🚗 Speedy Gonzales e
16-bit time stamp
Dec 6 16:14:40.187121 jlink:      triceExamples.c 34      29_073 16351 🚗 Speedy Gonzales f
16-bit time stamp
Dec 6 16:14:40.187121 jlink:      triceExamples.c 35      28_515 16350 🚗 Speedy Gonzales g
16-bit time stamp
Dec 6 16:14:40.187121 jlink:      triceExamples.c 36      27_957 16349 🚗 Speedy Gonzales h

```

```

16-bit time stamp
Dec 6 16:14:40.187121 jlink: triceExamples.c 42 27_093 16344 2.71828182845904523536
<- float number as string
Dec 6 16:14:40.187121 jlink: triceExamples.c 43 25_913 16343 2.71828182845904509080
(double with more ciphers than precision)
Dec 6 16:14:40.187121 jlink: triceExamples.c 44 25_310 16342 2.71828174591064453125
(float with more ciphers than precision)
Dec 6 16:14:40.187121 jlink: triceExamples.c 45 24_730 16341 2.718282 (default
rounded float)
Dec 6 16:14:40.187121 jlink: triceExamples.c 46 24_149 16340 A Buffer:
Dec 6 16:14:40.187121 jlink: triceExamples.c 47 23_577 16339 32 2e 37 31 38 32 38 31
38 32 38 34 35 39 30 34 35 32 33 35 33 36
Dec 6 16:14:40.187630 jlink: triceExamples.c 48 22_391 16338 31372e32 31383238
34383238 34303935 35333235
Dec 6 16:14:40.187690 jlink: triceExamples.c 49 21_290 16337
ARemoteFunctionName(2e32)(3137)(3238)(3138)(3238)(3438)(3935)(3430)(3235)(3533)(3633)
Dec 6 16:14:40.187690 jlink: triceExamples.c 50 16200 5 times a 16 byte long
Trice messages, which may not be written all if the buffer is too small:
Dec 6 16:14:40.187690 jlink: triceExamples.c 52 19_546 16335 i=44444400 aaaaaaa00
Dec 6 16:14:40.188195 jlink: triceExamples.c 52 18_930 16335 i=44444401 aaaaaaa01
Dec 6 16:14:40.188195 jlink: triceExamples.c 52 18_314 16335 i=44444402 aaaaaaa02
Dec 6 16:14:40.188195 jlink: triceExamples.c 52 17_698 16335 i=44444403 aaaaaaa03
Dec 6 16:14:40.188195 jlink: triceExamples.c 52 17_082 16335 i=44444404 aaaaaaa04
Dec 6 16:14:41.191648 jlink: triceLogDiagData.c 21 16382 RTT0_writeDepthMax=325
(BUFFER_SIZE_UP=1024)
Dec 6 16:14:41.191648 jlink: triceLogDiagData.c 44 16378 triceSingleDepthMax =
108 of 172 (TRICE_BUFFER_SIZE)
Dec 6 16:14:41.191648 jlink: triceExamples.c 29 0,030_628 16356 🎵 Speedy Gonzales a
32-bit time stamp
Dec 6 16:14:41.191648 jlink: triceExamples.c 30 0,030_072 16355 🎵 Speedy Gonzales b
32-bit time stamp

```

" Speedy Gonzales" needs about 500 MCU clocks.

28.6. A developer setting, only enabling SEGGER_RTT and without deferred output gives after running `./build.sh`
`TRICE DIAGNOSTICS=0 TRICE PROTECT=0`:

```
arm-none-eabi-size out/F030_inst.elf
      text      data      bss      dec      hex filename
    5796       16     2736    8548    2164 out/F030_inst.elf
```

That is nearly 1 KB less Flash needs.

The output:

```

ms@DESKTOP-7POEGPB MINGW64 ~/repos/trice_wt-devel/examples/F030_inst (devel)
$ trice l -p jlink -args "-Device STM32F030R8 -if SWD -Speed 4000 -RTTChannel 0" -pf none -d16 -showID
"deb:%5d"
Dec 6 16:20:10.545274 jlink:      triceExamples.c    12      65_535 16369 Hello! 🙌😊
Dec 6 16:20:10.545274 jlink:
Dec 6 16:20:10.545274 jlink:      🎉🎉🎉🎉🎉🎉🎉🎉🎉🎉🎉🎉🎉🎉
Dec 6 16:20:10.545274 jlink:      🎈🎈🎈🎈 NUCLEO-F030R8 🎈🎈🎈🎈
Dec 6 16:20:10.545274 jlink:      🍃🍃🍃🍃🍃🍃🍃🍃🍃🍃🍃🍃
Dec 6 16:20:10.545274 jlink:
Dec 6 16:20:10.545274 jlink:
Dec 6 16:20:10.545274 jlink:      triceExamples.c   61      16334 TRICE_DIRECT_OUTPUT ==
1, TRICE_DEFERRED_OUTPUT == 0
Dec 6 16:20:10.545274 jlink:      triceExamples.c   63      16333 TRICE_STACK_BUFFER,
TRICE_MULTI_PACK_MODE
Dec 6 16:20:10.545890 jlink:      triceExamples.c   76      16327 _CYCLE == 1, _PROTECT ==
0, _DIAG == 0, XTEA == 0
Dec 6 16:20:10.546396 jlink:      triceExamples.c   77      16326 _SINGLE_MAX_SIZE=104,
_BUFFFER_SIZE=172, _DEFERRED_BUFFFER_SIZE=1024
Dec 6 16:20:11.448885 jlink:      triceExamples.c   29      0,031_859 16356 🎶 Speedy Gonzales a
32-bit time stamp
Dec 6 16:20:11.448885 jlink:      triceExamples.c   30      0,031_661 16355 🎶 Speedy Gonzales b
32-bit time stamp

```

```

Dec 6 16:20:11.448885 jlink: triceExamples.c 31 0,031_463 16354 🎵 Speedy Gonzales c
32-bit time stamp
Dec 6 16:20:11.448885 jlink: triceExamples.c 32 0,031_265 16353 🎵 Speedy Gonzales d
32-bit time stamp
Dec 6 16:20:11.448885 jlink: triceExamples.c 33 31_067 16352 🎵 Speedy Gonzales e
16-bit time stamp
Dec 6 16:20:11.448885 jlink: triceExamples.c 34 30_867 16351 🎵 Speedy Gonzales f
16-bit time stamp
Dec 6 16:20:11.448885 jlink: triceExamples.c 35 30_667 16350 🎵 Speedy Gonzales g
16-bit time stamp
Dec 6 16:20:11.448885 jlink: triceExamples.c 36 30_467 16349 🎵 Speedy Gonzales h
16-bit time stamp
Dec 6 16:20:11.448885 jlink: triceExamples.c 42 29_961 16344 2.71828182845904523536
<- float number as string
Dec 6 16:20:11.549660 jlink: triceExamples.c 43 29_141 16343 2.71828182845904509080
(double with more ciphers than precision)
Dec 6 16:20:11.549660 jlink: triceExamples.c 44 28_897 16342 2.71828174591064453125
(float with more ciphers than precision)
Dec 6 16:20:11.549660 jlink: triceExamples.c 45 28_675 16341 2.718282 (default
rounded float)
Dec 6 16:20:11.549660 jlink: triceExamples.c 46 28_452 16340 A Buffer:
Dec 6 16:20:11.550166 jlink: triceExamples.c 47 28_238 16339 32 2e 37 31 38 32 38 31
38 32 38 34 35 39 30 34 35 32 33 35 33 36
Dec 6 16:20:11.550247 jlink: triceExamples.c 48 27_412 16338 31372e32 31383238
34383238 34303935 35333235
Dec 6 16:20:11.550247 jlink: triceExamples.c 49 26_671 16337
ARemoteFunctionName(2e32)(3137)(3238)(3138)(3238)(3438)(3935)(3430)(3235)(3533)(3633)
Dec 6 16:20:11.550247 jlink: triceExamples.c 50 16200 5 times a 16 byte long
Trice messages, which may not be written all if the buffer is too small:
Dec 6 16:20:11.550754 jlink: triceExamples.c 52 25_646 16335 i=444444400 aaaaaaa00
Dec 6 16:20:11.550754 jlink: triceExamples.c 52 25_389 16335 i=444444401 aaaaaaa01
Dec 6 16:20:11.550754 jlink: triceExamples.c 52 25_132 16335 i=444444402 aaaaaaa02
Dec 6 16:20:11.551285 jlink: triceExamples.c 52 24_875 16335 i=444444403 aaaaaaa03
Dec 6 16:20:11.551285 jlink: triceExamples.c 52 24_618 16335 i=444444404 aaaaaaa04
Dec 6 16:20:12.453968 jlink: triceExamples.c 29 0,031_859 16356 🎵 Speedy Gonzales a
32-bit time stamp
Dec 6 16:20:12.453968 jlink: triceExamples.c 30 0,031_661 16355 🎵 Speedy Gonzales b
32-bit time stamp

```

"🎵 Speedy Gonzales" direct output needs about 200 MCU clocks and not 500 as before.

28.7. Settings Conclusion

- 4-8 KB Flash and 1.2 KB RAM needed for the Trice library.
- The RAM size is mainly influenced by the configured buffer sizes.
- Switching off diagnostics and/or protection is ok for less memory needs and faster Trice execution after getting some experience with the project.

28.8. Legacy Trice Space Example (Old Version)

- STM32CubeMX generated empty default project: Program Size: Code=2208 R0-data=236 RW-data=4 ZI-data=1636
- Same project with default Trice instrumentation: Program Size: Code=2828 R0-data=236 RW-data=44 ZI-data=1836
- Needed FLASH memory: 620 Bytes
- Needed RAM: 40 Bytes plus 200 Bytes for the 2 times 100 Bytes double buffer
- With increased/decreased buffers also more/less RAM is needed.
- With each additional Trice macro a few additional FLASH memory bytes, like 10 assembler instructions, are needed.
- No printf-like library code is used anymore.
- No format strings go into the target code anymore.
- In general Trice instrumentation reduces the needed memory compared to a printf-like implementation.

28.9. Memory Needs for Old Example 1

The following numbers are measured with a legacy encoding, showing that the instrumentation code can be even smaller.

Program Size (STM32-F030R8 demo project)	trice instrumentation	buffer size	compiler optimize for time	comment
--	-----------------------	-------------	----------------------------	---------

Program Size (STM32-F030R8 demo project)	trice instrumentation	buffer size	compiler optimize for time	comment
Code=1592 RO-data=236 RW-data= 4 ZI-data=1028	none	0	off	CubeMX generated, no trice
Code=1712 RO-data=240 RW-data=24 ZI-data=1088	core	64	off	core added without trices
Code=3208 RO-data=240 RW-data=36 ZI-data=1540	TriceCheckSet()	512	off	TRICE_SHORT_MEMORY is 1 (small)
Code=3808 RO-data=240 RW-data=36 ZI-data=1540	TriceCheckSet()	512	on	TRICE_SHORT_MEMORY is 0 (fast)

- The core instrumentation needs less 150 bytes FLASH and about 100 bytes RAM when buffer size is 64 bytes.
- The about 50 trices in TriceCheckSet() allocate roughly 2100 (fast mode) or 1500 (small mode) bytes.
- trices are removable without code changes with `#define TRICE_OFF 1` before `include "trice.h"` on file level or generally on project level.

28.10. Memory Needs for Old Example 2

Project	Compiler	Optimization	Link-Time-Optimization	Result	Remark
MDK-ARM_STM32F030_bareerated	CLANG v6.19	-Oz	yes	Code=1020 RO-data=196 RW-data=0 ZI-data=1024	This is the plain generated project without trice instrumentation.
MDK-ARM_STM32F030_instrumented	CLANG v6.19	-Oz	yes	Code=4726 RO-data=238 RW-data=16 ZI-data=4608	This is with full trice instrumentation with example messages.

- The size need is less than 4 KB. See also [Trice Project Image Size Optimization](#).

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29. Trice Project Image Size Optimization

Modern compilers are optimizing out unused code automatically, but you can help to reduce trice code size if your compiler is not perfect.

29.1. Code Optimization -o3 or -oz (if supported)

For debugging it could be helpful to switch off code optimization what increases the code size. A good choice is `-o1`. See also [TRICE_STACK_BUFFER could cause stack overflow with -o0 optimization](#).

29.2. Compiler Independent Setting (a bit outdated)

Maybe the following is a bit unhandy but it decreases the code amount, build time and the image size.

- For **X=8|16|32|64** and **N=0...12** selectively set `#define ENABLE_triceXfn_N 1` to `0` for unused functions in project specific file `triceConfig.h`.
- For **X=8|16|32|64** and **N=0...12** selectively set `#define ENABLE_TriceXfn_N 1` to `0` for unused functions in project specific file `triceConfig.h`.
- For **X=8|16|32|64** and **N=0...12** selectively set `#define ENABLE_TRiceXfn_N 1` to `0` for unused functions in project specific file `triceConfig.h`.

When having lots of program memory simply let all values be `1`. With specific linker optimization unused functions can get stripped out automatically.

It is possible to `#define TRICE_SINGLE_MAX_SIZE 12` for example in `triceConfig.h`. This automaticaly disables all Trice messages with payloads > 8 bytes (Trice size is 4 bytes).

29.3. Linker Option --split-sections (if supported)

In ARM-MDK uVision `Project -> Options -> C/C++ -> "One EFL section for each function"` allows good optimization and getting rid of unused code without additional linker optimization. This leads to a faster build process and is fine for most cases. It allows excluding unused functions.

29.4. Linker Optimization -fIto (if supported)

- To get the smallest possible image, do *not* use option `--split sections`.
- Use linker optimization alone.
- This increases the build time but reduces the image size significantly.

29.4.1. ARMCC compiler v5 "Linker Feedback"

- In ARM-MDK uVision, when using ARMCC compiler v5, there is a check box `Project -> Options -> Target -> "Cross Module Optimization"`.
- In ARMCC this works also with the lite version.

29.4.2. ARMCLANG compiler v6 "Link-Time Optimization"

- In ARM-MDK uVision, when using ARMCLANG compiler v6, the check box `Project -> Options -> C/C++(AC6) -> "Link-Time Optimization"` is usable to set the CLI `-fIto` switch.
- LTO is not possible with ARMCLANG6 lite: <https://developer.arm.com/documentation/ka004054/latest>.

29.4.3. GCC

With GCC use the `-fIto` CLI switch directly.

29.4.4. LLVM ARM Clang

This compiler is much faster and creates the smallest images. Right now it uses the GCC libs and linker.

29.4.5. Other IDE's and compilers

Please check the manuals and create a pull request or simply let me know.

29.5. Legacy STM32F030 Example Project - Different Build Sizes

29.5.1. ARMCC compiler v5

Compiler	Linker	Result	Comment
o0		Code=46942 RO-data=266 RW-data=176 ZI-data=4896	very big
o1		Code=22582 RO-data=258 RW-data=168 ZI-data=4896	
o3		Code=21646 RO-data=258 RW-data=168 ZI-data=4896	
o0	split sections	Code= 7880 RO-data=268 RW-data=156 ZI-data=4892	for debugging
o1	split sections	Code= 5404 RO-data=260 RW-data=148 ZI-data=4892	for debugging
o3	split sections	Code= 4996 RO-data=260 RW-data=148 ZI-data=4892	good balance
o0	fIto	Code= 8150 RO-data=266 RW-data=176 ZI-data=4896	builds slower
o1	fIto	Code= 5210 RO-data=258 RW-data=148 ZI-data=4892	builds slower
o3	fIto	Code= 4818 RO-data=258 RW-data=148 ZI-data=4892	builds slower, smallest image

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30. Trice Tags and Color

30.1. How to get

- Add a tag name as color descriptor in front of each Trice format string like "`wrn:Peng!`".
- In file `../internal/emitter/lineTransformerANSI.go` the colors are changeable and additional color tags definable.
- It is possible to concatenate single colorized letters to get output like this:

```
Nov 29 22:42:37.962401 COM7: 15747 ABa:cde
Nov 29 22:42:37.962401 COM7: 15703 fCHtJk
Nov 29 22:42:37.962401 COM7: 15653 1234712123
```

- `../_test/testdata/triceCheck.c` contains the code for this example.

- The Trice tool, if knowing `wrn:` as pattern, prepends the appropriate color code. It removes the sequence `wrn:`, if it is known and completely lower case.
- The user can define any pattern with any color code to create colored output with the Trice tool.
- There is no tag enable switch inside the target code. It would need a back channel and add overhead.
- An option using tag specific ID ranges with optional routing exists.
- The Trice tool offers the 2 command line switches `-pick` and `-ban` to control tag visualization during runtime.

30.1.1. Output options

```

main.c: 155      41      NUCLEO-F030R8      TRICE_MODE 200
main.c: 155      42
main.c: 155      44
main.c: 155      46      Trice 2x half buffer size:1000
main.c: 155      51
main.c: 162      67      x = 5.934 = 5.934, 5.934
main.c: 163      70      1/11 = 0.09090909
main.c: 197      10000008 MSG: ❤ START select = 0, TriceDepthMax = 152
main.c: 199      10000013 MSG: ✎ STOP select = 0, TriceDepthMax = 152
main.c: 207      10000017 10000016 µs - ReadUs32() lasts 36 ticks
main.c: 197      20000008 MSG: ❤ START select = 10, TriceDepthMax = 152
triceCheck.c: 89  20000012 FATAL:magenta+b:red
triceCheck.c: 90  20000014 CRITICAL:red+i:default+h
triceCheck.c: 91  20000016 EMERGENCY:red+i:blue
triceCheck.c: 92  20000018 ERROR:11:red
triceCheck.c: 93  20000020 WARNING:11+i:red
triceCheck.c: 94  20000022 ATTENTION:11:green
triceCheck.c: 95  20000024 INFO:cyan+b:default+h
triceCheck.c: 96  20000025 DEBUG:130+i
triceCheck.c: 97  20000027 TRACE:default+i:default+h
triceCheck.c: 98  20000029 TIME:blue+i:blue+h
triceCheck.c: 99  20000031 MESSAGE:green+h:black
triceCheck.c: 100 20000033 READ:black+i:yellow+h
triceCheck.c: 101 20000035 WRITE:black+u:yellow+h
triceCheck.c: 102 20000037 RECEIVE:black+h:black
triceCheck.c: 103 20000038 TRANSMIT:black:black+h
triceCheck.c: 104 20000040 DIAG:yellow+i:default+h
triceCheck.c: 105 20000042 INTERRUPT:magenta+i:default+h
triceCheck.c: 106 20000044 SIGNAL:118+i
triceCheck.c: 107 20000046 TEST:yellow+h:black
triceCheck.c: 108 20000048 DEFAULT:off
triceCheck.c: 109 20000050 NOTICE:blue:white+h
triceCheck.c: 110 20000051 ALERT:magenta:magenta+h
triceCheck.c: 111 20000053 ASSERT:yellow+i:blue
triceCheck.c: 112 20000055 ALARM:red+i:white+h
triceCheck.c: 113 20000057 CYCLE:blue+i:default+h
triceCheck.c: 114 20000059 VERBOSE:blue:default
    main.c: 199  20000061 MSG: ✎ STOP select = 10, TriceDepthMax = 352
    main.c: 207  20000065 20000064 µs - ReadUs32() lasts 36 ticks
    main.c: 197  30000008 MSG: ❤ START select = 20, TriceDepthMax = 376
triceCheck.c: 117 30000013 magenta+b:red
triceCheck.c: 118 30000014 red+i:default+h
triceCheck.c: 119 30000016 red+i:blue
triceCheck.c: 120 30000018 11:red
triceCheck.c: 121 30000020 11+i:red
triceCheck.c: 122 30000022 11:green
triceCheck.c: 123 30000024 cyan+b:default+h
triceCheck.c: 124 30000026 130+i
triceCheck.c: 125 30000027 default+i:default+h
triceCheck.c: 126 30000029 time:blue+i:blue+h
triceCheck.c: 127 30000031 green+h:black
triceCheck.c: 128 30000033 black+i:yellow+h
triceCheck.c: 129 30000035 black+u:yellow+h
triceCheck.c: 130 30000037 black+h:black
triceCheck.c: 131 30000039 black:black+h
triceCheck.c: 132 30000040 yellow-i:default+h
triceCheck.c: 133 30000042 magenta+i:default+h
triceCheck.c: 134 30000044 118+i
triceCheck.c: 135 30000046 yellow+h:black
triceCheck.c: 136 30000048 off
triceCheck.c: 137 30000050 blue:white+h
triceCheck.c: 138 30000052 alert:magenta:magenta+h
triceCheck.c: 139 30000053 yellow+i:blue
triceCheck.c: 140 30000055 red+i:white+h
triceCheck.c: 141 30000057 blue+i:default+h
triceCheck.c: 142 30000059 blue:default
    main.c: 199  30000061 MSG: ✎ STOP select = 20, TriceDepthMax = 376
    main.c: 207  30000065 30000064 µs - ReadUs32() lasts 36 ticks
    main.c: 197  40000008 MSG: ❤ START select = 30, TriceDepthMax = 376
triceCheck.c: 145 40000013 Hi!
triceCheck.c: 146 40000014 Hi!

```

30.1.2. Check Alternatives

There are over 1000 possibilities:

```

1087:      green+B:default+h:green+B:default+h
1088:      green+u:default+h:green+u:default+h
1089:      green+i:default+h:green+i:default+h
1090:      green+s:default+h:green+s:default+h
1091:      green+h:default+h:green+h:default+h
1092:          yellow:default+h:yellow:default+h
1093:      yellow+b:default+h:yellow+b:default+h
1094:      yellow+B:default+h:yellow+B:default+h
1095:      yellow+u:default+h:yellow+u:default+h
1096:      yellow+i:default+h:yellow+i:default+h
1097:      yellow+s:default+h:yellow+s:default+h
1098:      yellow+h:default+h:yellow+h:default+h
1099:          blue:default+h:blue:default+h
1100:      blue+b:default+h:blue+b:default+h
1101:      blue+B:default+h:blue+B:default+h
1102:      blue+u:default+h:blue+u:default+h
1103:      blue+i:default+h:blue+i:default+h
1104:      blue+s:default+h:blue+s:default+h
1105:      blue+h:default+h:blue+h:default+h
1106:      magenta:default+h:magenta:default+h
1107:      magenta+b:default+h:magenta+b:default+h

```

To see them all run `trice generate -color`. Only file `../internal/emitter/lineTransformerANSI.go` needs to be changed and the Trice tool needs to be rebuild afterwards: `go install ./...`. If you design a good looking flavour, feel free to propose it.

30.2. Color issues under Windows

Currently console colors are not enabled by default in Win10, so if you see no color but escape sequences on your powershell or cmd window, please refer to [Windows console with ANSI colors handling](#) or simply use a Linux like terminal under windows, like git-bash. One option is also to install Microsoft *Windows Terminal (Preview)* from inside the Microsoft store and to start the Trice tool inside there. Unfortunately this can not be done automatically right now because of missing command line switches. [Alacritty](#) is one of other alternatives.

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31. Trice without UART

A very performant output path is RTT, if your MCU supports background memory access like the ARM-M ones.

Because the Trice tool needs only to receive, a single target UART-TX pin will do. But it is also possible to use a GPIO-Pin for Trice messages without occupying a UART resource.

- This slow path is usable because a Trice needs only few bytes for transmission.
- You can transmit each basic trice (4 or 8 bytes) as bare message over one pin:

Figure 1 shows the transitions to transmit an arbitrary binary value in biphase encoding—to be more specific, this variant is biphase mark coding. In the biphase encoding scheme, there is a transition at the start of each bit.

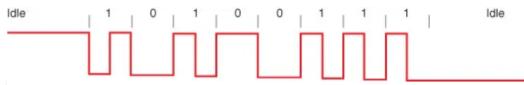


Figure 1: This is an example of a binary value transferred in biphase mark coding.

For a 1 bit there is also a transition halfway through the clock period. With a 0 bit, there is no extra transition. The absolute levels in biphase encoding are irrelevant, only the changes in the output line are important. In the previous example, the transmission starts with the idle state at a high logic level but ends in an idle state at a low logic level.

```
void trace_out(int byte, int iopin)
{
    int bit;
    for (bit = 0; bit < 8; bit++) {
        toggle_pin(iopin);
        trace_delay();
        if ((byte & 0x80) != 0)
            toggle_pin(iopin);
        trace_delay();
        byte <= 1;
    }
}
```

Listing 1: Transmitting a byte in biphase encoding, based on a function to toggle an I/O pin, is shown.

The biphase encoding signal goes from the DUT to a trace dongle. The dongle decodes the signal and forwards it as serial data from a virtual RS-232 port to the workstation (see Photo 2 and the circuit in Figure 2).

- The 2 images are taken from <https://circuitcellar.com/cc-blog/a-trace-tool-for-embedded-systems/>. See there for more information.
- As Trice dongle you can use any spare MCU board with an UART together with an FTDI USB converter.
 - This allowes also any other data path - method does'nt matter:
 [UART](#),
[I²C](#),
[SPI](#),
[GPIO](#),
[CAN](#),
[LIN](#), ...
- [RTT](#) is also a possible path to use - see [Segger RTT](#) for options.

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32. Trice over RTT

Allows Trice over the debug probe without using a pin or UART.

- RTT works good with a SEGGER J-Link debug probe but needs some closed source software components.
- Also ST-Link is usable for Trice logs, but maybe not parallel with debugging.
- Most investigations where done with a [NUCLEO64-STM32F030R8 evaluation board](#) which contains an on-board debug probe reflashed with a SEGGER J-Link OB software (see below).
 - When using very high Trice loads over RTT for a long time, sometimes an on-board J-Link (re-flashed ST-Link) could get internally into an inconsistent state (probably internal buffer overrun), what needs a power cycle then.
- You could consider RTT over open-OCD as an alternative.
- The default SEGGER up-buffer size is 1024 bytes, enough for most cases. If not, adapt it in your `triceConfig.h` file. You need only one up-channel for Trice:

```
#define BUFFER_SIZE_UP (1024) // "TRICE_DIRECT_BUFFER_SIZE"
```

- Possible: Parallel usage of RTT direct mode with UART deferred mode. You can define `TRICE_UARTA_MIN_ID` and `TRICE_UARTA_MAX_ID` inside `triceConfig.h` to log only a specific ID range over UARTA in deferred mode for example. ([#446](#))

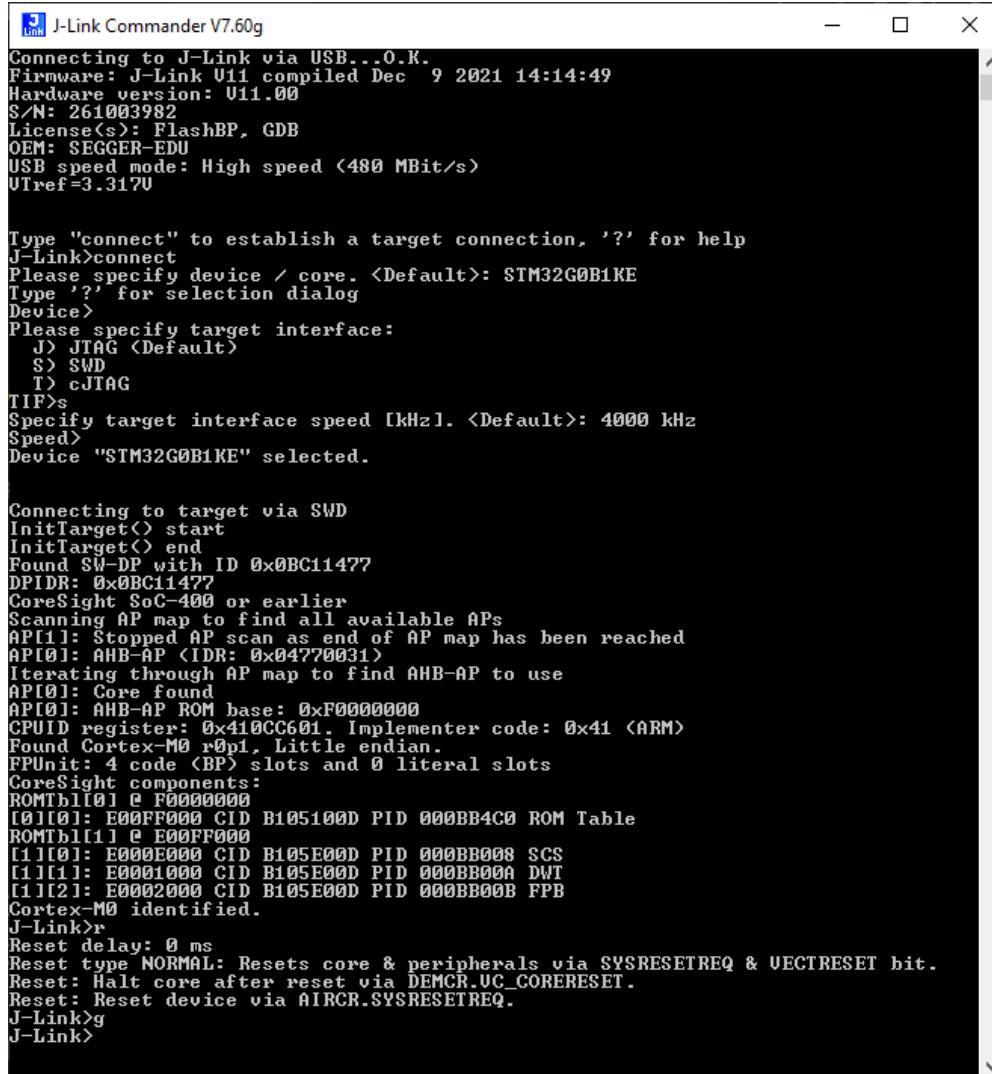
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32.1. For the impatient (2 possibilities)

The default SEGGER tools only support RTT channel 0.

32.1.1. Start JLink commander and connect over TCP

- JLink.exe → **connect ↳ ↳ S ↳** and keep it active.
 - You can control the target with **r[eset]**, **g[o]**, **h[alt]** and use other commands too.



```

J-Link Commander V7.60g
Connecting to J-Link via USB...O.K.
Firmware: J-Link V11 compiled Dec 9 2021 14:14:49
Hardware version: V11.00
S/N: 261003982
License(s): FlashBP, GDB
OEM: SEGGER-EDU
USB speed mode: High speed <480 MBit/s>
VRef=3.317V

Type "connect" to establish a target connection, '?' for help
J-Link>connect
Please specify device / core. <Default>: STM32G0B1KE
Type '?' for selection dialog
Device>
Please specify target interface:
  J) JTAG <Default>
  S) SWD
  T) cJTAG
TIF>s
Specify target interface speed [kHz]. <Default>: 4000 kHz
Speed>
Device "STM32G0B1KE" selected.

Connecting to target via SWD
InitTarget() start
InitTarget() end
Found SW-DP with ID 0x0BC11477
DPIDR: 0x0BC11477
CoreSight SoC-400 or earlier
Scanning AP map to find all available APs
AP[1]: Stopped AP scan as end of AP map has been reached
AP[0]: AHB-AP <IDR: 0x04770031>
Iterating through AP map to find AHB-AP to use
AP[0]: Core found
AP[0]: AHB-AP ROM base: 0xF0000000
CPUID register: 0x410CC601. Implementer code: 0x41 <ARM>
Found Cortex-M0 r0p1, Little endian.
FPUnit: 4 code <BP> slots and 0 literal slots
CoreSight components:
ROMTable[0] @ F0000000
[0][0]: E00FF000 CID B105100D PID 000BB4C0 ROM Table
ROMTable[1] @ E00FF000
[1][0]: E000E000 CID B105E00D PID 000BB008 SCS
[1][1]: E0001000 CID B105E00D PID 000BB00A DWT
[1][2]: E0002000 CID B105E00D PID 000BB00B FPB
Cortex-M0 identified.
J-Link>r
Reset delay: 0 ms
Reset type NORMAL: Resets core & peripherals via SVSRESETREQ & UECTRESEST.
Reset: Halt core after reset via DEMCR.UC_CORERESET.
Reset: Reset device via AIRCR.SYSRESETREQ.
J-Link>g
J-Link>

```

- Start in Git-Bash or s.th. similar: **trice l -p TCP4 -args localhost:19021**
- You may need a Trice tool restart after firmware reload.

Setup TCP4 server providing the trace data

This is just the SEGGER J-Link server here for demonstration, but if your target device has an TCP4 interface, you can replace this with your target server.

```

ms@DESKTOP-7P0EGPB MINGW64 ~/repos/trice (master)
$ jlink
SEGGER J-Link Commander V7.92g (Compiled Sep 27 2023 15:36:46)
DLL version V7.92g, compiled Sep 27 2023 15:35:10

Connecting to J-Link via USB...O.K.
Firmware: J-Link STLink V21 compiled Aug 12 2019 10:29:20
Hardware version: V1.00
J-Link uptime (since boot): N/A (Not supported by this model)
S/N: 770806762
VRef=3.300V

Type "connect" to establish a target connection, '?' for help
J-Link>connect
Please specify device / core. <Default>: STM32G0B1RE
Type '?' for selection dialog

```

```

Device>
Please specify target interface:
J) JTAG (Default)
S) SWD
T) cJTAG
TIF>s
Specify target interface speed [kHz]. <Default>: 4000 kHz
Speed>
Device "STM32G0B1RE" selected.

Connecting to target via SWD
InitTarget() start
SWD selected. Executing JTAG -> SWD switching sequence.
DAP initialized successfully.
InitTarget() end - Took 36.3ms
Found SW-DP with ID 0x0BC11477
DPv0 detected
CoreSight SoC-400 or earlier
Scanning AP map to find all available APs
AP[1]: Stopped AP scan as end of AP map has been reached
AP[0]: AHB-AP (IDR: 0x04770031)
Iterating through AP map to find AHB-AP to use
AP[0]: Core found
AP[0]: AHB-AP ROM base: 0xF0000000
CPUID register: 0x410CC601. Implementer code: 0x41 (ARM)
Found Cortex-M0 r0p1, Little endian.
FPUnit: 4 code (BP) slots and 0 literal slots
CoreSight components:
ROMTbl[0] @ F0000000
[0][0]: E00FF000 CID B105100D PID 000BB4C0 ROM Table
ROMTbl[1] @ E00FF000
[1][0]: E000E000 CID B105E00D PID 000BB008 SCS
[1][1]: E0001000 CID B105E00D PID 000BB00A DWT
[1][2]: E0002000 CID B105E00D PID 000BB00B FPB
Memory zones:
Zone: "Default" Description: Default access mode
Cortex-M0 identified.
J-Link>

```

Now the TCP4 server is running and you can start the Trice tool as TCP4 client, which connects to the TCP4 server to receive the binary log data:

```
$ trice l -p TCP4 -args="127.0.0.1:19021" -til ..../examples/G0B1_inst/til.json -li
..../examples/G0B1_inst/li.json -d16 -pf none
```

In this **G0B1_inst** example we use the additional **-d16** and **-pf none** switches to decode the RTT data correctly.

This is a demonstration and test for the **-port TCP4 usage possibility.** Using RTT with J-Link is more easy possible as shown in the next point.

32.1.2. Start using JLinkRTTLogger

- Start inside Git-Bash or s.th. similar: **trice l -p JLINK -args "-Device STM32F030R8 -if SWD -Speed 4000 -RTTChannel 0"**
 - Replace CLI details with your settings.
 - For **G0B1_inst**: **trice l -p JLINK -args "-Device STM32G0B1RE -if SWD -Speed 4000 -RTTChannel 0" -d16 -pf none**
 - You can add the **-verbose** CLI switch for more details.
- You may **not** need a Trice tool restart after firmware reload.

32.1.3. JLinkRTTLogger Issue

- For some reason the RTT technique does not work well with Darwin and also Linux right now. The problem seems to be that the JLinkRTTLogger app cannot work correctly in the background. But there is a workaround:
 - Example 1:

- In one terminal run `JLinkRTTLogger -Device STM32G0B1RE -if SWD -Speed 4000 -RTTChannel 0 myLogFile.bin`
 - and in an other terminal execute `trice l -p FILE -args myLogFile.bin -pf none -d16.`
 - Example 2:
 - Flash, start debugger and run to main()
 - Terminal 1: `rm ./temp/trice.bin && JLinkRTTLogger -Device STM32G0B1RE -If SWD -Speed 4000 -RTTChannel 0 ./temp/trice.bin`
 - Terminal 2: `touch ./temp/trice.bin && trice log -p FILE -args ./temp/trice.bin -prefix off -hs off -d16 -ts ms -i ../../demoTIL.json -li ../../demoLI.json -pf none`
 - Continue to run in debugger
 - Terminal 1:

```
th@P51-DebianKDE:~/repos/trice/examples/G0B1_inst$ rm ./temp/trice.bin && JLinkRTTLogger  
-Device STM32G0B1RE -If SWD -Speed 4000 -RTTChannel 0 ./temp/trice.bin  
SEGGER J-Link RTT Logger  
Compiled Dec 18 2024 15:48:21  
(c) 2016-2017 SEGGER Microcontroller GmbH, www.segger.com  
Solutions for real time microcontroller applications  
  
Default logfile path: /home/th/.config/SEGGER  
  
-----  
  
Connected to:  
SEGGER J-Link ST-LINK  
S/N: 779220206  
  
Searching for RTT Control Block...OK.  
1 up-channels found:  
0: Terminal  
Selected RTT Channel description:  
Index: 0  
Name: Terminal  
Size: 1024 bytes.  
  
Output file: ./temp/trice.bin  
  
Getting RTT data from target. Press any key to quit.  
-----  
  
Transfer rate: 0 Bytes/s Data written: 15.71 KB
```

- #### ■ Terminal 2:

```

triceExamples.c 30 0:00:00,003 Speedy Gonzales b 32-bit time stamp
triceExamples.c 31 0:00:00,003 Speedy Gonzales c 32-bit time stamp
triceExamples.c 32 0:00:00,003 Speedy Gonzales d 32-bit time stamp
triceExamples.c 33 0,310 Speedy Gonzales e 16-bit time stamp
triceExamples.c 34 0,328 Speedy Gonzales f 16-bit time stamp
triceExamples.c 35 0,347 Speedy Gonzales g 16-bit time stamp
triceExamples.c 36 0,365 Speedy Gonzales h 16-bit time stamp
triceExamples.c 42 0,394 2.71828182845904523536 <- float number as
string
    triceExamples.c 43 0,436 2.71828182845904509080 (double with more
ciphers than precision)
    triceExamples.c 44 0,458 2.71828174591064453125 (float with more
ciphers than precision)
    triceExamples.c 45 0,479 2.718282 (default rounded float)
    triceExamples.c 46 0,500 A Buffer:
    triceExamples.c 47 0,520 32 2e 37 31 38 32 38 31 38 32 38 34 35 39 30 34
35 32 33 35 33 36
    triceExamples.c 48 0,562 31372e32 31383238 34383238 34303935
35333235
    triceExamples.c 49 0,601 ARemoteFunctionName(2e32)(3137)(3238)(3138)
(3238)(3438)(3935)(3430)(3235)(3533)(3633)
    triceExamples.c 50 3 times a 16 byte long Trice messages, which
may not be written all if the buffer is too small:
    triceExamples.c 52 0,664 i=44444400 aaaaaa00
    triceExamples.c 52 0,687 i=44444401 aaaaaa01
    triceExamples.c 52 0,709 i=44444402 aaaaaa02
        main.c 312 0:00:00,003 StartDefaultTask
        main.c 339 0:00:00,003 StartTask02:Diagnostics and TriceTransfer
triceLogDiagData.c 21 RTT0_writeDepthMax=365 (BUFFER_SIZE_UP=1024)
triceLogDiagData.c 44 triceSingleDepthMax = 96 of 172
(TRICE_BUFFER_SIZE)
triceLogDiagData.c 75 triceRingBufferDepthMax = 0 of 2000
triceCheck.c 57 line 57
triceCheck.c 59 0:00:02,325 Hello World!
triceCheck.c 61 0:00:02,405 This is a message without values and a 32-bit
stamp.
    triceCheck.c 62 0,306 This is a message without values and a 16-bit
stamp.
    triceCheck.c 63 This is a message without values and without
stamp.

```

- See also the configuration in `./examples/GOB1_inst/Core/triceConfig.h`
 - If you install the `tmux` command your life gets easier by using a shell script like `./examples/GOB1_inst/RTTIlogTmux.sh`

```
mkdir -p ./temp  
rm -f ./temp/trice.bin  
touch ./temp/trice.bin  
tmux new -s "tricerttlog" -d "JLinkRTTLogger -Device STM32G0B1RE -If SWD -Speed 4000 -RTTChannel 0  
./temp/trice.bin"  
trice log -p FILE -args ./temp/trice.bin -pf none -prefix off -hs off -d16 -ts16 "time:offs:%4d µs" -  
showID "deb:%5d" -i ../../demoTIL.json -li ../../demoLI.json -stat  
tmux kill-session -t "tricerttlog"
```

- Usage:

```
_DEFERRED_BUFFER_SIZE=2000
triceExamples.c    29  0:00:00,002 🎵 Speedy Gonzales a 32-bit time stamp
```

- **Hint:** If you use *RTTLogTmux.sh* with Darwin, the "control-C" key combination seems not to work immediately. That is simply because the keyboard focus switches away after script start. Simply click into the terminal window again and then use "control-C" to terminate the Trice logging.

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32.2. Segger Real Time Transfer (RTT)

- Prerequisite is a processor with memory background access support like ARM Cortex-M cores.
- If you can use a Segger J-Link or an STM ST-Link debug probe (ST Microelectronics eval boards have it) this is an easy and fast way to use Trice without any UART or other port.
- Detailed description can be found in document [UM08001_JLink.pdf](#) in chapter 16 which is part of <https://www.segger.com/downloads/jlink/#J-LinkSoftwareAndDocumentationPack>.
- Following examples are for Windows, but should work similar also on Linux and Darwin (MacOS).
- Trice can use the Segger RTT protocol in different ways.
 - Hardware paths:
 - Use [J-Link](#) or [J-Link OB \(on-board\)](#). J-Link OB can be flashed to many ST Microelectronics evaluation boards (v2.0 link hardware) and for example is also usable with NXP and Atmel. For that you can also use a spare STM32 evaluation board (10 EUR) with jumper changes and breakout wires.
 - Use ST-Link with [gostlink](#). It uses only one USB endpoint so debugging and Trice output in parallel is not possible.
 - Use some other Debug-Probe with target memory access (support welcome)
 - RTT channel selection (on target and on host)
 - RECOMMENDED:
 - `trice l -p JLINK` or shorter `trice l` for STM32F030R8 (default port is JLINK) starts in background a `JLinkRTTLogger.exe` which connects to J-Link and writes to a logfile which in turn is read by the Trice tool. On exit the `JLinkRTTLogger.exe` is killed automatically.
 - It expects a target sending messages over RTT channel 0 (zero). Chapter 16.3.3 in [UM08001_JLink.pdf](#) refers to "Up-Channel 1" but this maybe is a typo and probably a 0 is mend. The `JLinkRTTLogger.exe` main advantage against other free available SEGGER tools is, that all bytes are transferred. Other SEGGER tools assume ASCII characters and use `FF 00` to `FF 0F` as a terminal switch command and filter that out causing Trice data disturbances.
 - It should be possible to start several instances on on different targets using `-SelectEmuBySN <SN>` inside the `-args` Trice CLI switch.
 - `JLinkRTTLogger` binaries for Linux & Darwin can be found at <https://www.segger.com/downloads/jlink/>.
 - `trice l -p STLINK` starts in background a `trice/third_party/goST/stRttLogger.exe` which connects to ST-Link and writes to a logfile which in turn is read by the Trice tool. On exit the `stRttLogger.exe` is killed automatically. It expects a target sending messages over RTT channel 0 (other channels supported too but may not work).
 - It is possible to start several instances on different channels as well as on different targets. The source code is in <https://github.com/bbnote/gostlink> and should work also at least under Linux.
 - If you have the choice, prefer J-Link. It allows parallel debugging and Trice output.
 - The full `-args` string is normally required and depends on the used device. Example: `trice l -args="-Device STM32F070RB -if SWD -Speed 4000 -RTTChannel 0 -RTTSearchRanges 0x20000000_0x1000"`. The `-RTTSearchRanges` part is mostly optional.
 - Enter `trice h -log` and read info for `-args` switch:

```
-args string
Use to pass port specific parameters. The "default" value depends on the used port:
port "COMn": default="", use "TARM" for a different driver. (For baud rate settings see -
baud.)
port "J-LINK": default="-Device STM32F030R8 -if SWD -Speed 4000 -RTTChannel 0 -RTTSearchRanges
0x20000000_0x1000",
The -RTTSearchRanges "..." need to be written without extra "" and with _ instead of
space.
For args options see JLinkRTTLogger in SEGGER UM08001_JLink.pdf.
port "ST-LINK": default="-Device STM32F030R8 -if SWD -Speed 4000 -RTTChannel 0 -
RTTSearchRanges 0x20000000_0x1000",
The -RTTSearchRanges "..." need to be written without extra "" and with _ instead of
space.
For args options see JLinkRTTLogger in SEGGER UM08001_JLink.pdf.
```

```
port "BUFFER": default="0 0 0 0", Option for args is any byte sequence.
(default "default")
```

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32.3. J-Link option

- Prerequisite is a SEGGER J-Link debug probe or a development board with an on-board J-Link option.

32.3.1. Convert Evaluation Board onboard ST-Link to J-Link

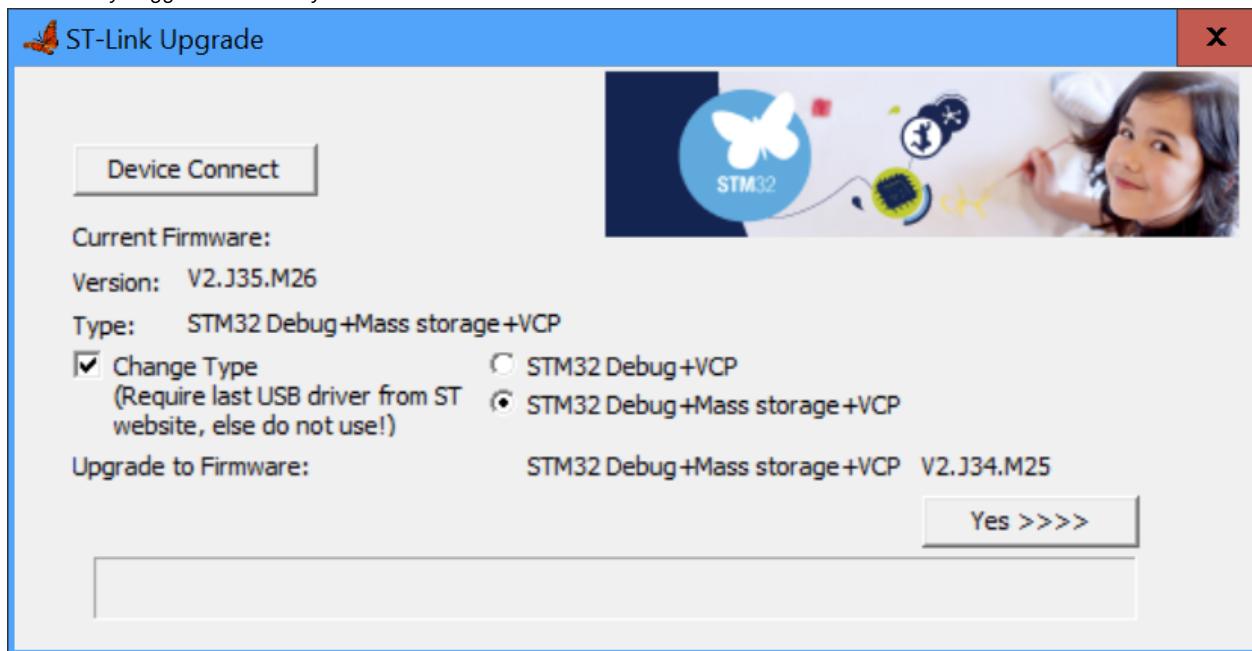
- Following steps describe the needed action for a ST Microelectronics evaluation board and windows - adapt them to your environment.
- It is always possible to turn back to the ST-Link OB firmware with the SEGGER [STLinkReflash.exe](#) tool but afterwards the ST-Link Upgrade tool should be used again to get the latest version.

First step (to do if some issues occur - otherwise you can skip it)

[Video](#)

See also <https://github.com/stlink-org/stlink>

- Get & install [STM32 ST-LINK utility](#)
- Run from default install location "[C:\Program Files \(x86\)\STMicroelectronics\STM32 ST-LINK Utility\ST-LinkUpgrade.exe](C:\Program Files (x86)\STMicroelectronics\STM32 ST-LINK Utility\ST-LinkUpgrade.exe)"
- Enable checkbox [Change Type](#) and select radio button [STM32 Debug+Mass storage + VCP](#). The [STM32Debug+ VCP](#) won't be detected by Segger reflash utility.



Second step

- Check Converting ST-LINK On-Board Into a J-Link
- Use [STLinkReflash.exe](#) to convert NUCLEO from ST-Link on-board to J-Link on-board. [STM32 Debug+ VCP](#) won't be detected by Segger reflash utility.

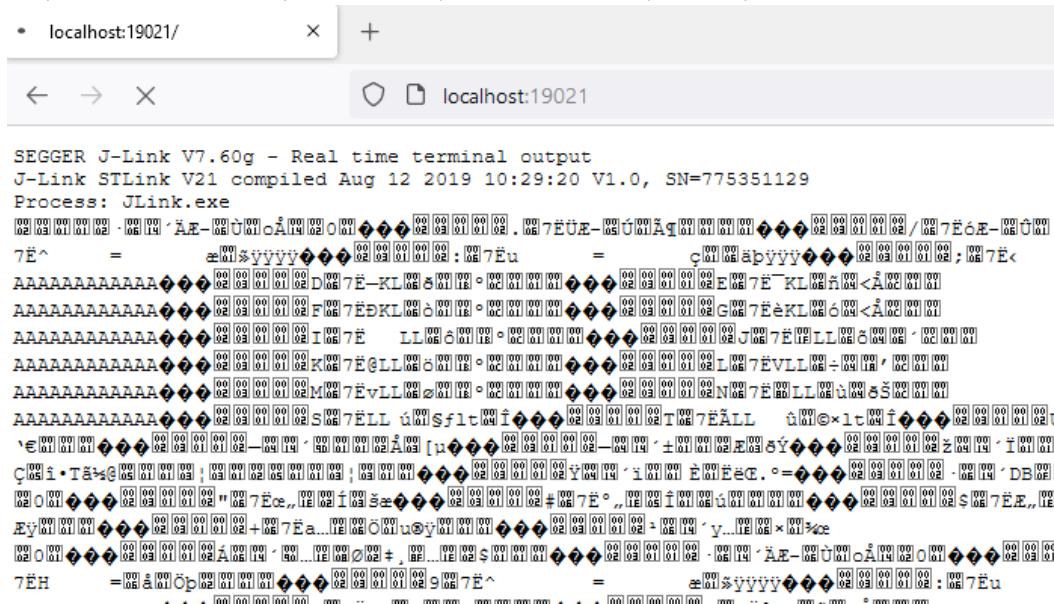
32.3.2. Some SEGGER tools in short

- Download [J-Link Software and Documentation Pack](#) and install.
 - You may need to add <C:\Program Files\SEGGER\JLink> to the %PATH% variable.
- Tested with [NUCLEO64-STM32F030R8](#) evaluation board.
- For example: Compile and flash [../examples/F030_inst](#) project.
 - Check in [..examples/F030_inst/Core/Inc/triceConfig.h](#) if `#define TRICE_RTT_CHANNEL 0` is set as output option.

[JLink.exe](#)

- [JLink.exe](#) is the SEGGER J-Link commander. It starts the **J-Link driver/server** and one can connect to it

- Info found [here](#):
 - J-Link Commander can be started with different command line options for test and automation
 - purposes. In the following, the command line options which are available for J-Link
 - Commander are explained. All command line options are case insensitive.
 - Command Explanation
 - AutoConnect Automatically start the target connect sequence
 - CommanderScript Passes a CommandFile to J-Link
 - CommandFile Passes a CommandFile to J-Link
 - Device Pre-selects the device J-Link Commander shall connect to
 - ExitOnError Commander exits after error.
 - If Pre-selects the target interface
 - IP Selects IP as host interface
 - JLinkScriptFile Passes a JLinkScriptFile to J-Link
 - JTAGConf Sets IRPre and DRPre
 - Log Sets logfile path
 - RTT TelnetPort Sets the RTT Telnetport
 - SelectEmuBySN Connects to a J-Link with a specific S/N over USB
 - SettingsFile Passes a SettingsFile to J-Link
 - Speed Starts J-Link Commander with a given initial speed
- Documentation: https://wiki.segger.com/J-Link_Commander
- If you run successful `jlink -device STM32F030R8 -if SWD -speed 4000 -autoconnect 1` the target is stopped.
 - To let it run you need manually execute `go` as command in the open jlink window.
 - To automate that create a text file named for example `jlink.go` containing the `go` command: `echo go > jlink.go` and do a `jlink -device STM32F030R8 -if SWD -speed 4000 -autoconnect 1 -CommandFile jlink.go`
- It is possible to see some output with Firefox (but not with Chrome?) for example:



- After closing the Firefox the Trice tool can connect to it too:

- Open a commandline and run:

```
trice log -port TCP4 -args localhost:19021
```

- Trice output is visible
- With `halt` and `go` inside the Jlink window the MCU can get halted and released
- It is possible in parallel to debug-step with a debugger (tested with ARM-MDK)

```

$ T.Hoehleinleitner@DT-03023-TH MINGW64 /c/repos/trice.rokath (master)
$ llink -device STM32F030R8 -if SWD -speed 4000 -autoconnect 1
SEGGER J-Link Commander V7.60g (Compiled Feb 2 2022 10:34:58)
DLL version 6.00, compiled Feb 2 2022 10:33:42

Connecting to J-Link via USB...OK.
Firmware: J-Link STLINK V2I compiled Aug 12 2019 10:29:20
Hardware: V2I Version: V1.00
5V/1A
VRef=3.300V
Device "STM32F030R8" selected.

Connecting to target via SWD
InitTarget() start
InitTarget() end
Found SWD-Port with ID 0X08B11477
CPU: ARM Cortex-M0+ @ 48MHz
CoreSight SoC-400 or earlier
Scanning AP map to find all available APs
AP[1]: Stopped AP scan as end of AP map has been reached
AP[0]: AHB-AP (IDR: 0x40700201)
Iterating through AP map to find HAB-AP to use
AP[0]: Core Found
AP[0]: AHB-AP ROM base: 0xE000F000
AP[0]: ROM register: 0x410C200, Implementer code: 0x41 (ARM)
Found Core ROM >0x0, Little endian.
EPUnit: 4 code (BP) slots and 0 literal slots
CoreSight components:
ROMB[0] @ E000F000
[0][0]: E000E000 CID BILOSE00 PID 000B0008 SCS
[0][1]: E0001000 CID BILOSE00 PID 000B000A DWT
[0][2]: E0002000 CID BILOSE00 PID 000B0008 FPB
Cortex-M0 identified.
J-Link reset
J-Link reset
Reset delay: 0 ms
Reset type NORMAL: Resets core & peripherals via SYSESETREQ & VECTRESET bit.
Reset: Halt core after reset via DEMCR.VC_COREREST.
Reset: Reset device via AIRCR.SYSESETREQ.
J-Link quit

T.Hoehleinleitner@DT-03023-TH MINGW64 /c/repos/trice.rokath (master)
$ |
```

- **PLUS:**

- Works reliable.
 - No file interface needed.
 - Trice can connect over TCP localhost:19021 and display logs over RTT channel 0.
 - The open `jlink` CLI can be handy to control the target: `[r]eset`, `[g]o`. `[h]alt`
 - No need to restart the Trice tool after changed firmware download.

- **MINUS:**

- Uses RTT up-channel 0 and therefore RTT up-channel 0 is not usable differently.
 - No down-channel usable.
 - Needs a separate manual start of the `jlink` binary with CLI parameters.
 - I would not recommend to automate that too, because this step is needed only once after PC power on

JLinkRTTLogger.exe

- **JLinkRTTLogger.exe** is a CLI tool and connects via the SEGGER API to the target. It is usable for writing RTT channel 0 data from target into a file.

- **PLUS:**

- Works reliable.
 - Is automatable.
 - Create file with raw log data: `JLinkRTTLogger.exe -Device STM32F030R8 -if SWD -Speed 4000 -RTTChannel 0 triceRaw.log`

- ```
It is possible to evaluate this file offline: trice l -p FILE -args triceRaw.log
T.Hoehenleitner@DT-03023-TH MINGW64 /c/repos/trice.rokath (master)
$ trice l -p FILE -args triceRaw.log
Read ID List file C:\repos\trice.rokath\til.json with 1211 items.
Feb 6 21:54:39.016430 FILE: main.c: 151 39 NUCLEO-F030R8 TRICE_MODE 0
Feb 6 21:54:39.016938 FILE: main.c: 151 74 Single Trice Stack buf size: 128
Feb 6 21:54:39.016938 FILE: main.c: 151 96
Feb 6 21:54:39.016938 FILE: main.c: 151 115
Feb 6 21:54:39.016938 FILE: main.c: 151 177
Feb 6 21:54:39.017462 FILE: main.c: 158 207 x = 5.934 = 5.934, 5.934
Feb 6 21:54:39.017462 FILE: main.c: 159 239 1/11 = 0.09090909
Feb 6 21:54:39.017462 FILE: main.c: 183 1000004 MSG: ❤ START select = 0, TriceDepthMax = 48
Feb 6 21:54:39.017462 FILE: main.c: 185 1000029 MSG: ✎ STOP select = 0, TriceDepthMax = 48
Feb 6 21:54:39.017462 FILE: main.c: 193 1000053 1000052 µs - ReadUs32() lasts 36 ticks
Feb 6 21:54:39.017462 FILE: main.c: 183 2000004 MSG: ❤ START select = 10, TriceDepthMax = 48
Feb 6 21:54:39.018007 FILE: triceCheck.c: 34 2000028 Various single arguments
Feb 6 21:54:39.018007 FILE: triceCheck.c: 35 2000048 TRICE8 line false (%t ,0)
Feb 6 21:54:39.018007 FILE: triceCheck.c: 36 2000070 TRICE8 line true (%t ,2)
Feb 6 21:54:39.018007 FILE: triceCheck.c: 37 2000092 TRICE8 line 255 (%u ,-1)
Feb 6 21:54:39.018007 FILE: triceCheck.c: 38 2000114 TRICE8 line 11111111 (%b ,-1)
Feb 6 21:54:39.018007 FILE: triceCheck.c: 39 2000136 TRICE8 line 377 (%o ,-1)
Feb 6 21:54:39.018007 FILE: triceCheck.c: 40 2000158 TRICE8 line 0o377 (%o ,-1)
Feb 6 21:54:39.018007 FILE: triceCheck.c: 41 2000180 TRICE8 line FF (%X ,-1)
Feb 6 21:54:39.018007 FILE: triceCheck.c: 42 2000202 TRICE8 line ff (%x ,-1)
Feb 6 21:54:39.018515 FILE: triceCheck.c: 43 2000225 TRICE8 line -1 (%d ,-1)
Feb 6 21:54:39.018515 FILE: main.c: 185 2000249 MSG: ✎ STOP select = 10, TriceDepthMax = 48
Feb 6 21:54:39.018515 FILE: main.c: 193 2000272 2000271 µs - ReadUs32() lasts 36 ticks
Feb 6 21:54:39.018515 FILE: main.c: 183 3000004 MSG: ❤ START select = 20, TriceDepthMax = 48
```

- No need to restart the Trice tool after changed firmware download.

**NUS:**

  - Logs in a file, so the Trice tool needs to read from that file.
  - Maybe cannot write in a file as background process on Darwin

- The Trice tool can watch the output file and display the Trices: `trice log -port JLINK -args "-Device STM32F030R8 -if SWD -Speed 4000 -RTTChannel 0"

```
T.Hoehenleitner@DT-03023-TH MINGW64 /c/repos/trice.rokath (master)
$ trice log -port JLINK -args "-Device STM32F030R8 -if SWD -Speed 4000 -RTTChannel 0"

Read ID List file C:\repos\trice.rokath\til.json with 1211 items.
Feb 6 21:03:37.215526 JLINK: main.c: 151 39 NUCLEO-F030R8 TRICE_MODE 0
Feb 6 21:03:37.215526 JLINK: main.c: 151 74 Single Trice Stack buf size: 128
Feb 6 21:03:37.215526 JLINK: main.c: 151 96
Feb 6 21:03:37.215526 JLINK: main.c: 151 115
Feb 6 21:03:37.215526 JLINK: main.c: 151 177
Feb 6 21:03:37.216491 JLINK: main.c: 158 207 x = 5.934 = 5.934, 5.934
Feb 6 21:03:37.216491 JLINK: main.c: 159 239 1/11 = 0.09090909
Feb 6 21:03:37.664352 JLINK: main.c: 183 1000004 MSG: 🌟 START select = 0, TriceDepthMax = 48
Feb 6 21:03:37.664352 JLINK: main.c: 185 1000029 MSG: ✘ STOP select = 0, TriceDepthMax = 48
Feb 6 21:03:37.665301 JLINK: main.c: 193 1000053 1000052 µs - ReadUs32() lasts 36 ticks
Feb 6 21:03:38.656395 JLINK: main.c: 183 2000004 MSG: 🌟 START select = 10, TriceDepthMax = 48
Feb 6 21:03:38.656395 JLINK: triceCheck.c: 34 2000028 Various single arguments
Feb 6 21:03:38.656395 JLINK: triceCheck.c: 35 2000048 TRICE8 line false (%t ,0)
Feb 6 21:03:38.656395 JLINK: triceCheck.c: 36 2000070 TRICE8 line true (%t ,2)
Feb 6 21:03:38.656395 JLINK: triceCheck.c: 37 2000092 TRICE8 line 255 (%u ,-1)
Feb 6 21:03:38.657361 JLINK: triceCheck.c: 38 2000114 TRICE8 line 11111111 (%b ,-1)
Feb 6 21:03:38.657361 JLINK: triceCheck.c: 39 2000136 TRICE8 line 377 (%o ,-1)
Feb 6 21:03:38.657361 JLINK: triceCheck.c: 40 2000158 TRICE8 line 00377 (%o ,-1)
Feb 6 21:03:38.657361 JLINK: triceCheck.c: 41 2000180 TRICE8 line FF (%X ,-1)
Feb 6 21:03:38.657361 JLINK: triceCheck.c: 42 2000202 TRICE8 line ff (%x ,-1)
Feb 6 21:03:38.657361 JLINK: triceCheck.c: 43 2000225 TRICE8 line -1 (%d ,-1)
Feb 6 21:03:38.657361 JLINK: main.c: 185 2000249 MSG: ✘ STOP select = 10, TriceDepthMax = 48
Feb 6 21:03:38.658358 JLINK: main.c: 193 2000272 2000271 µs - ReadUs32() lasts 36 ticks
Feb 6 21:03:39.651140 JLINK: main.c: 183 3000004 MSG: 🌟 START select = 20, TriceDepthMax = 48
Feb 6 21:03:39.651140 JLINK: triceCheck.c: 46 3000028 TRICE16_1 line false (%t ,0)
Feb 6 21:03:39.651140 JLINK: triceCheck.c: 47 3000051 TRICE16_1 line true (%t ,2)
Feb 6 21:03:39.651140 JLINK: triceCheck.c: 48 3000073 TRICE16_1 line 65535 (%u -1)
Feb 6 21:03:39.651140 JLINK: triceCheck.c: 49 3000095 TRICE16_1 line 111111111111111111111111 (%b -1)
Feb 6 21:03:39.652142 JLINK: triceCheck.c: 50 3000117 TRICE16_1 line 177777 (%o -1)
Feb 6 21:03:39.652142 JLINK: triceCheck.c: 51 3000139 TRICE16_1 line ffff (%x -1)
Feb 6 21:03:39.652142 JLINK: main.c: 185 3000164 MSG: ✘ STOP select = 20, TriceDepthMax = 48
Feb 6 21:03:39.652142 JLINK: main.c: 193 3000187 3000186 µs - ReadUs32() lasts 36 ticks

2 times: att attention Attention ATT ATTENTION
35 times: Timestamp tim time TIM TIME TIMESTAMP timestamp
7 times: m msg message M MSG MESSAGE
15 times: rd rd_ RD RD_
6 times: s sig signal S SIG SIGNAL

T.Hoehenleitner@DT-03023-TH MINGW64 /c/repos/trice.rokath (master)
```

### 32.3.3. JLinkRTTClient.exe

- JLinkRTTClient.exe** can be used for simple text transmitting to the target, it also displays strings from target coming over channel 0. It is not used by the Trice tool.
  - PLUS:**
    - Target stimulation with proprietary protocol over RTT down-channel 0 possible.
  - MINUS:**
    - Unfortunately it cannot run separately parallel to stimulate the target with any proprietary protocol because it connects to localhost:19021 and therefore blockades the only one possible connection.

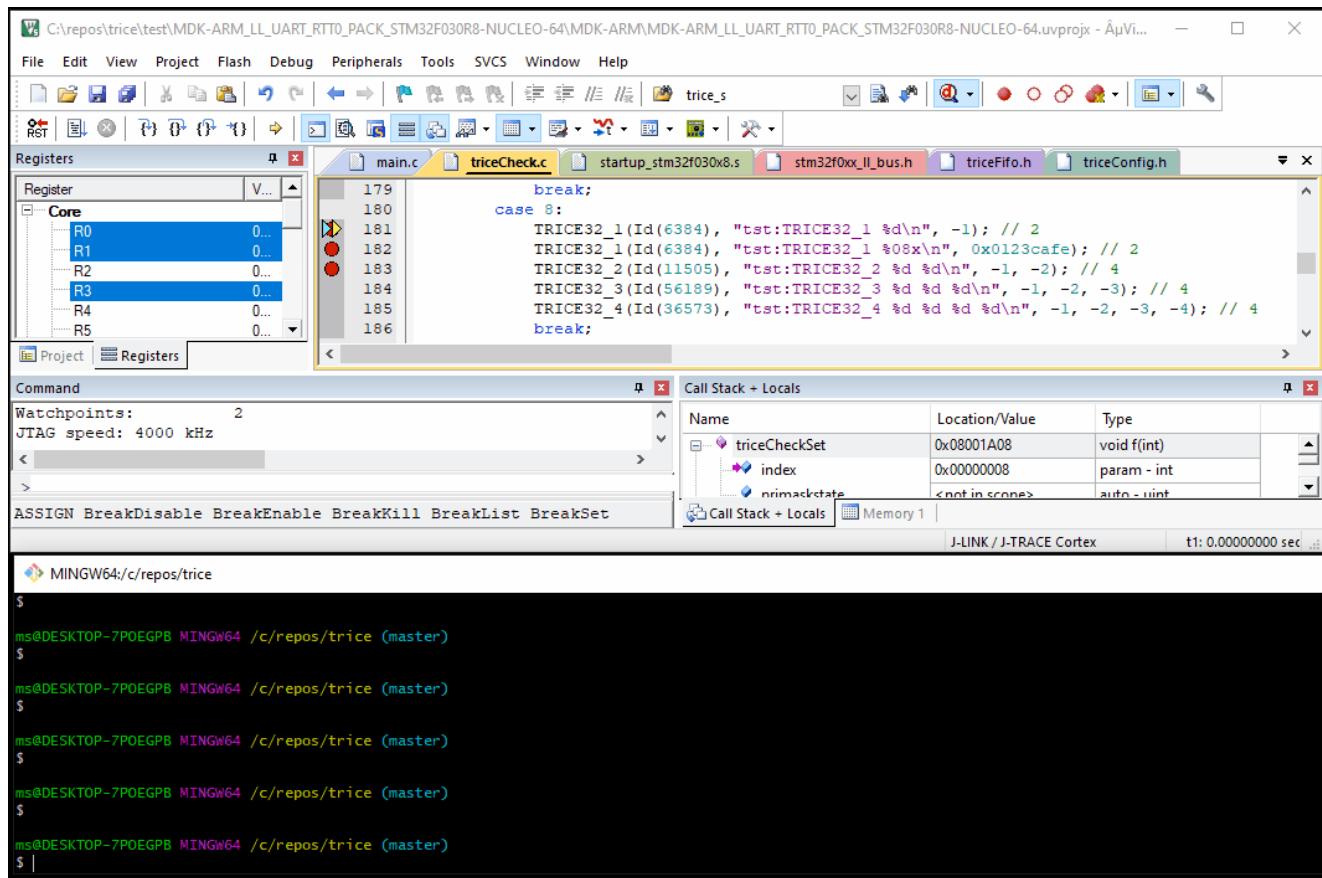
### 32.3.4. JLinkRTTViewer.exe

- JLinkRTTViewer.exe** is a GUI tool and connects via the SEGGER API to the target. It expects ASCII codes and is not used by the Trice tool. The switching between the 16 possible terminals is done via **FF 00 ... FF 0F**. These byte pairs can occur inside the Trice data.

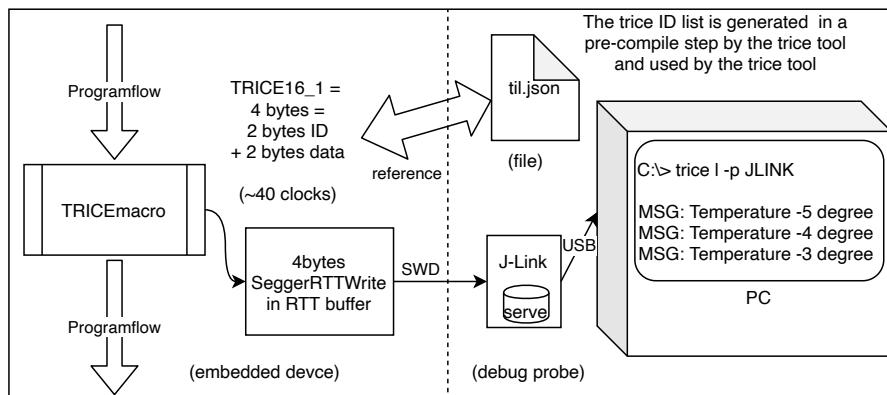
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## 32.4. Segger RTT

- The main advantages are:
  - Speed
  - No **TriceTransfer()** nor any interrupt is needed in the background
  - No UART or other output is needed
- This is, because automatically done by SeggerRTT. This way one can debug code as comfortable as with **printf()** but with all the TRICE advantages. Have a look here:



- Avoid Trice buffering inside target and write with TRICE macro directly into the RTT buffer (direct Trice mode = `#define TRICE_MODE 0` inside `triceConfig.h`).
- Write the bytes per Trice directly (little time & some space overhead on target, but no changes on host side)



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### 32.5. Segger J-Link SDK (~800 EUR) Option

- Segger offers a SeggerRTT SDK which allows to use more than just channel 0 and you can develop your own tooling with it.
- The `trice -port JLINK` is ok for usage as is right now. However if you wish more comfort check here:
- Question: [How-to-access-multiple-RTT-channels](#)
  - "Developer pack used to write your own program for the J-Link. Please be sure you agree to the terms of the associated license found on the Licensing Information tab before purchasing this SDK. You will benefit from six months of free email support from the time that this product is ordered."
- The main [Segger J-Link SDK](#) disadvantage beside closed source and payment is: **One is not allowed to distribute binaries written with the SDK.** That makes it only interesting for company internal automatization.

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### 32.6. Additional Notes (leftovers)

- [Downloading RTT target package](#) from <https://www.segger.com/products/debug-probes/j-link/technology/about-real-time-transfer/>.

- Read the manual [UM08001\\_JLink.pdf](#).
- Extract `../third_party/segger.com/SEGGER_RTT_V760g.zip` to `../third_party/segger.com/SEGGER_RTT`. Check for an update @ SEGGER.
- Add `SEGGER_RTTI.c` to target project

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### 32.7. Further development

- Check OpenOCD!
  - Use OpenOCD and its built-in RTT feature. OpenOCD then starts a server on localhost:17001 where it dumps all RTT messages.
- The GoST project offers a way bypassing JLINK. Used -port STLINK instead.
- Maybe `libusb` together with `libjaylink` offer some options too.
- Checkout <https://github.com/deadsy/jaylink>.
- "C:\Program Files (x86)\SEGGER\JLink\JMem.exe" shows a memory dump.
- Go to <https://libusb.info/>
  - -> Downloads -> Latest Windows Binaries
  - extract `libusb-1.0.23` (or later version)

```
libusb-1.0.23\examples\bin64> .\listdevs.exe
2109:2811 (bus 2, device 8) path: 6
1022:145f (bus 1, device 0)
1022:43d5 (bus 2, device 0)
0a12:0001 (bus 2, device 1) path: 13
1366:0105 (bus 2, device 10) path: 5
```

- Repeat without connected Segger JLink

```
libusb-1.0.23\examples\bin64> .\listdevs.exe
2109:2811 (bus 2, device 8) path: 6
1022:145f (bus 1, device 0)
1022:43d5 (bus 2, device 0)
0a12:0001 (bus 2, device 1) path: 13
```

- In this case `1366:0105 (bus 2, device 10) path: 5` is missing, so `vid=1366, did=0105` as example
- On Windows install WSL2. The real Linux kernel is needed for full USB access.

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### 32.8. NUCLEO-F030R8 example

Info: <https://www.st.com/en/evaluation-tools/nucleo-f030r8.html>

#### 32.8.1. RTT with original on-board ST-LINK firmware

- `#define TRICE_RTT_CHANNEL 0`:
- If you use a NUCLEO-F030R8 with the original ST-Link on board after firmware download enter: `trice l -p ST-LINK -args "-Device STM32F030R8 -if SWD -Speed 4000 -RTTChannel 0 -RTTSearchRanges 0x20000000_0x2000"`. After pressing the

reset button output becomes visible:

```
T.Hoehenleitner@DT-03023-TH MINGW64 /c/repos/trice.rokath (master)
$ trice l -p ST-LINK -args "-Device STM32F030R8 -if SWD -Speed 4000 -RTTChannel 0 -RTTSearchRanges 0x20000000_0x2000"
Read ID List file C:\repos\trice.rokath\til.json with 1192 items.
Jan 23 00:56:31.883693 ST-LINK: main.c: 151 40 NUCLEO-F030R8 TRICE_MODE 200
Jan 23 00:56:31.883693 ST-LINK: main.c: 151 42 Trice 2x half buffer size:1000
Jan 23 00:56:31.883693 ST-LINK: main.c: 151 44
Jan 23 00:56:31.883693 ST-LINK: main.c: 151 46
Jan 23 00:56:31.883693 ST-LINK: main.c: 151 51
Jan 23 00:56:31.883693 ST-LINK: main.c: 158 67 x = 5.934 = 5.934, 5.934
Jan 23 00:56:31.883693 ST-LINK: main.c: 159 70 1/11 = 0.09090909
Jan 23 00:56:32.864984 ST-LINK: main.c: 183 1000007 MSG: ❤ START select = 0, TriceDepthMax = 152
Jan 23 00:56:32.865949 ST-LINK: main.c: 185 1000012 MSG: ✎ STOP select = 0, TriceDepthMax = 152
Jan 23 00:56:32.865949 ST-LINK: main.c: 193 1000016 1000015 µs - ReadUs32() lasts 36 ticks
Jan 23 00:56:33.910727 ST-LINK: main.c: 183 2000007 MSG: ❤ START select = 10, TriceDepthMax = 152
Jan 23 00:56:33.910727 ST-LINK: triceCheck.c: 33 2000012 Various single arguments
Jan 23 00:56:33.910727 ST-LINK: triceCheck.c: 34 2000014 TRICE8 line false (%t ,0)
Jan 23 00:56:33.910727 ST-LINK: triceCheck.c: 35 2000016 TRICE8 line true (%t ,2)
Jan 23 00:56:33.910727 ST-LINK: triceCheck.c: 36 2000017 TRICE8 line 255 (%u ,-1)
Jan 23 00:56:33.911729 ST-LINK: triceCheck.c: 37 2000019 TRICE8 line 11111111 (%b ,-1)
Jan 23 00:56:33.911729 ST-LINK: triceCheck.c: 38 2000021 TRICE8 line 377 (%o ,-1)
Jan 23 00:56:33.911729 ST-LINK: triceCheck.c: 39 2000023 TRICE8 line 0o377 (%o ,-1)
Jan 23 00:56:33.911729 ST-LINK: triceCheck.c: 40 2000025 TRICE8 line FF (%X ,-1)
Jan 23 00:56:33.911729 ST-LINK: triceCheck.c: 41 2000027 TRICE8 line ff (%x ,-1)
Jan 23 00:56:33.911729 ST-LINK: triceCheck.c: 42 2000029 TRICE8 line -1 (%d ,-1)
Jan 23 00:56:33.911729 ST-LINK: main.c: 185 2000031 MSG: ✎ STOP select = 10, TriceDepthMax = 196
```

- It works with both ST-Link variants (with or without mass storage device.)

### 32.8.2. Change to J-LINK onboard firmware

The screenshot shows a terminal window titled 'C:\repos\trice.rokath\third\_party\segger.com\STLinkReflash\_190812\STLinkReflash.exe'. The window displays a menu with options [0] Quit, [1] Upgrade to J-Link, [2] Update J-Link firmware, and [3] Restore ST-Link. The user has selected option [2]. The terminal output shows the process of preparing for FW update, identifying the ST-LINK variant as ST-LINK/V2-1, and performing the firmware update. The process is completed successfully.

```
[0] Quit
[1] Upgrade to J-Link
[2] Update J-Link firmware
[3] Restore ST-Link
Selection>1

Preparing for FW update (can take up to 10 seconds)...O.K.
Identifying ST-LINK variant...O.K.: ST-LINK/V2-1
Performing firmware update...O.K.

[0] Quit
[1] Upgrade to J-Link
[2] Update J-Link firmware
[3] Restore ST-Link
Selection>2

Switching to ST-Link bootloader...O.K.
Waiting for ST-LINK BTL to enumerate (can take 2 seconds)...O.K.
Preparing for FW update (can take up to 10 seconds)...O.K.
Identifying ST-LINK variant...O.K.: ST-LINK/V2-1
Performing firmware update...O.K.

[0] Quit
[1] Upgrade to J-Link
[2] Update J-Link firmware
[3] Restore ST-Link
Selection>
```

### 32.8.3. RTT with J-LINK firmware on-board

```
T.Hoehenleitner@DT-03023-TH MINGW64 /c/repos/trice.rokath (master)
$ trice l -p J-LINK -args "-Device STM32F030R8 -if SWD -Speed 4000 -RTTChannel 0 -RTTSearchRanges 0x20000000_0x2000"
Read ID List file C:\repos\trice.rokath\til.json with 1192 items.
Jan 23 01:09:47.170489 J-LINK: main.c: 151 40 NUCLEO-F030R8 TRICE_MODE 200
Jan 23 01:09:47.170489 J-LINK: main.c: 151 42 Trice 2x half buffer size:1000
Jan 23 01:09:47.170489 J-LINK: main.c: 151 44
Jan 23 01:09:47.170489 J-LINK: main.c: 151 46
Jan 23 01:09:47.170489 J-LINK: main.c: 151 51
Jan 23 01:09:47.170489 J-LINK: main.c: 158 67 x = 5.934 = 5.934, 5.934
Jan 23 01:09:47.170489 J-LINK: main.c: 159 70 1/11 = 0.09090909
Jan 23 01:09:47.726793 J-LINK: main.c: 183 1000007 MSG: ❤ START select = 0, TriceDepthMax = 152
Jan 23 01:09:47.726793 J-LINK: main.c: 185 1000012 MSG: ✎ STOP select = 0, TriceDepthMax = 152
Jan 23 01:09:47.726793 J-LINK: main.c: 193 1000016 1000015 µs - ReadUs32() lasts 36 ticks
Jan 23 01:09:48.725748 J-LINK: triceCheck.c: 33 2000007 MSG: ❤ START select = 10, TriceDepthMax = 152
Jan 23 01:09:48.725748 J-LINK: triceCheck.c: 34 2000012 Various single arguments
Jan 23 01:09:48.725748 J-LINK: triceCheck.c: 35 2000014 TRICE8 line false (%t ,0)
Jan 23 01:09:48.725748 J-LINK: triceCheck.c: 35 2000016 TRICE8 line true (%t ,2)
```

- Observations:
  - When pressing the black reset button, you need to restart the Trice tool.
  - When restarting the Trice tool, a target reset occurs.

- Other channel numbers than 0 seem not to work for some reason.

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### 32.9. Possible issues

- These boards seem not to work reliable with RTT over J-Link on-board firmware.
    - NUCLEO-G071RB
    - NUCLEO\_G031K8
  - After flashing back the ST-LINK OB firmware with the SEGGER tool, it is recommended to use the ST tool to update the ST-LINK OB firmware. Otherwise issues could occur.

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## 32.10. OpenOCD with Darwin

- OpenOCD on MacOS works out of the box after installing it.
  - When using VS code with Cortex-Debug you cannot use OpenOCD at the same time.
  - The `openocd.cfg` file is taylored to the flashed on-board J-Link adapter.

## Terminal 1:

```
brew install open-ocd
...
cd ./trice/examples/G0B1_inst
openocd -f openocd.cfg
Open On-Chip Debugger 0.12.0
Licensed under GNU GPL v2
For bug reports, read
 http://openocd.org/doc/doxygen/bugs.html
srst_only separate srst_nogate srst_open_drain connect_deassert_srst

Info : Listening on port 6666 for tcl connections
Info : Listening on port 4444 for telnet connections
Info : J-Link STLink V21 compiled Aug 12 2019 10:29:20
Info : Hardware version: 1.00
Info : VTarget = 3.300 V
Info : clock speed 2000 kHz
Info : SWD DPIDR 0x0bc11477
Info : [stm32g0x.cpu] Cortex-M0+ r0p1 processor detected
Info : [stm32g0x.cpu] target has 4 breakpoints, 2 watchpoints
Info : starting gdb server for stm32g0x.cpu on 3333
Info : Listening on port 3333 for gdb connections
Info : rtt: Searching for control block 'SEGGER RTT'
Info : rtt: Control block found at 0x20001238
Info : Listening on port 9090 for rtt connections
Channels: up=1, down=0
Up-channels:
0: Terminal 1024 0
Down-channels:

Info : Listening on port 6666 for tcl connections
Info : Listening on port 4444 for telnet connections
```

## Terminal 2:

```

with more ciphers than precision)
Nov 14 17:32:33.607518 TCP4: triceExamples.c 18 0_117 2.71828174591064453125 (float
with more ciphers than precision)
Nov 14 17:32:33.707851 TCP4: triceExamples.c 19 0_146 2.718282 (default rounded
float)
Nov 14 17:32:33.807685 TCP4: triceExamples.c 20 0_175 A Buffer:
Nov 14 17:32:33.908202 TCP4: triceExamples.c 21 0_204 32 2e 37 31 38 32 38 31 38 32
38 34 35 39 30 34 35 32 33 35 33 36
Nov 14 17:32:34.007148 TCP4: triceExamples.c 22 0_254 31372e32 31383238 34383238
34303935 35333235
Nov 14 17:32:35.007949 TCP4: triceExamples.c 23 0_301 ARemoteFunctionName(2e32)(3137)
(3238)(3138)(3238)(3438)(3935)(3430)(3235)(3533)(3633)
Nov 14 17:32:35.112304 TCP4: triceExamples.c 24 100 times a 16 byte long Trice
messages, which not all will be written because of the TRICE_PROTECT:
Nov 14 17:32:35.307567 TCP4: triceExamples.c 26 0_379 i=44444400 aaaaaa00
Nov 14 17:32:35.408257 TCP4: triceExamples.c 27 0,000_002 i=44444400 aaaaaa00
Nov 14 17:32:35.509022 TCP4: triceExamples.c 26 0_441 i=44444401 aaaaaa01
Nov 14 17:32:35.609439 TCP4: triceExamples.c 27 0,000_002 i=44444401 aaaaaa01
Nov 14 17:32:35.710201 TCP4: triceExamples.c 26 0_504 i=44444402 aaaaaa02
...

```

## 32.11. Links

- <https://www.codeinsideout.com/blog/stm32j-link-rtt/> (A good explanation of SEGGER J-Link Realtime Transfer - Fast Debug protocol: - only suitable for ASCII transfer)
- [USB over WSL2?](#) (Maybe interesting for OpenOCD)
- <https://kickstartembedded.com/2024/03/26/openocd-one-software-to-rule-debug-them-all/?amp=1>
- <https://mcuoneclipse.com/2021/10/03/visual-studio-code-for-c-c-with-arm-cortex-m-part-9-rtt/>

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# 33. Trice Target Code Implementation

## 33.1. TRICE Macro structure

### 33.1.1. TRICE\_ENTER

- Optionally disable interrupts.
- Prepare **TriceBufferWritePosition** and keep its initial value.

### 33.1.2. TRICE\_PUT

- Use and increment **TriceBufferWritePosition**.

### 33.1.3. TRICE\_LEAVE

- Use **TriceBufferWritePosition** and its initial value for data transfer
- Optionally restore interrupt state.

## 33.2. TRICE\_STACK\_BUFFER

- TRICE\_ENTER**: Allocate stack
- TRICE\_LEAVE**: Call `TriceDirectOut()`

## 33.3. TRICE\_STATIC\_BUFFER

- This is like **TRICE\_STACK\_BUFFER** but avoids stack allocation, what is better for many stacks.
- TRICE\_ENTER**: Set `TriceBufferWritePosition` to buffer start.
- TRICE\_LEAVE**: Call `TriceDirectOut()`.

## 33.4. TRICE\_DOUBLE\_BUFFER

- TRICE\_ENTER**: Keep `TriceBufferWritePosition`.
- TRICE\_LEAVE**: Optionally call `TriceDirectOut()`.

## 33.5. TRICE\_RING\_BUFFER

- **TRICE\_ENTER:** Keep or wrap TriceBufferWritePosition and add offset.
- **TRICE\_LEAVE:** Optionally call TriceDirectOut().

The **TRICE\_RING\_BUFFER** allocates incremental ring buffer space and each trice location is read by a deferred task.

### 33.6. Deferred Out

#### 33.6.1. Double Buffer

- TriceTransfer
  - TriceOut
  - TriceNonBlockingWrite( triceID, enc, encLen );

#### 33.6.2. Ring Buffer

- TriceTransfer
  - lastWordCount = TriceSingleDeferredOut(addr);
    - int triceID = TriceIDAndBuffer( pData, &wordCount, &pStart, &Length );
    - TriceNonBlockingWrite( triceID, pEnc, encLen );

### 33.7. Direct Transfer

- TRICE\_LEAVE
  - TriceDirectWrite(triceSingleBufferStartWritePosition, wordCount);
    - optional RTT32 with optional XTEAwithCOBS
    - optional RTT8 with optional XTEAwithCOBS
    - optional
      - triceIDAndLen
      - triceDirectEncode
      - triceNonBlockingDirectWrite

### 33.8. Possible Target Code Improvements

There have been 3 similar implementations for trice encode

```
static size_t triceDirectEncode(uint8_t* enc, const uint8_t * buf, size_t len);
size_t TriceDeferredEncode(uint8_t* enc, const uint8_t * buf, size_t len);

unsigned TriceEncryptAndCobsFraming32(uint32_t * const triceStart, unsigned wordCount){
```

Now:

```
size_t TriceEncode(unsigned encrypt, unsigned framing, uint8_t* dst, const uint8_t * buf, size_t len
){
```

- unsigned TriceEncryptAndCobsFraming32( uint32\_t \* const triceStart, unsigned wordCount ){

Currently there are 3 similar implementations for trice buffer reads

```
static size_t triceIDAndLen(uint32_t* pBuf, uint8_t** ppStart, int* triceID);
static int TriceNext(uint8_t** buf, size_t* pSize, uint8_t** pStart,
size_t* pLen);
static int TriceIDAndBuffer(uint32_t const * const pData, int* pWordCount, uint8_t** ppStart,
size_t* pLength);
```

- The TriceID is only needed for routing and can go in a global variable just for speed.
- The source buffer should be `uint32_t const * const`.
- The destination should be given with `uint32_t * const` and the return value is the trice netto size. For efficiency the result should be ready encoded.

```
/// \param pTriceID is filled with ID for routing
/// \param pCount is used for double or ring buffer to advance inside the buffer
```

```
///! \param dest provides space for the encoded trice
///! \param src is the location of the trice message we want encode
///! \retval is the netto size of the encoded trice data
size_t TriceEncode(int* pTriceID, unsigned int pCount, uint32_t * const dest, uint32_t const * const
src);
```

- This function interface is used for all cases.
- First we use the existing code for implementation and then we clean the code.

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## 34. Trice Similarities and Differences to printf Usage

### 34.1. Printf-like functions

...have a lot of things to do: Copy format string from FLASH memory into a RAM buffer and parse it for format specifiers. Also parse the variadic parameter list and convert each parameter according to its format specifier into a character sequences, what includes several divisions - costly function calls. Concatenate the parts to a new string and deliver it to the output, what often means copying again. A full-featured printf library consumes plenty space and processing time and several open source projects try to make it better in this or that way. Never ever call a printf-like function in time critical code, like an interrupt - it would crash your target in most cases. The `trice` calls are usable inside interrupts, because they only need a few MCU clocks for execution. Porting legacy code to use it with the Trice library, means mainly to replace Printf-like function calls with `trice` function calls.

### 34.2. Trice IDs

- Each Trice carries a 14-bit number ID as replacement for the format string.
- This ID is automatically generated (controllable) and in the source code it is the first parameter inside the Trice macro followed by the format string and optional values.
- The user can decide not to spoil the code by having the IDs permanently in its source code, by just inserting them as a pre-compile step with `trice insert` and removing them as a post-compile step with `trice clean`.
  - The Trice cache makes this invisible to the build system, allowing full translation speed.
- The format string is **not** compiled into the target code. It goes together with the ID into a project specific reference list file `til.json` (example).

### 34.3. Trice values bit width

- No need to explicitly express the value bit width.
- The default parameter width for the Trice macro is 32 bit. It is changeable to 8, 16 or 64-bit:

- Adapt `TRICE_DEFAULT_PARAMETER_BIT_WIDTH` inside `triceConfig.h`. It influences

```
238 //
239 // Default TRICE macro bitwidth: 32 (optionally adapt to MCU bit width)
240 //
241
242 #define TRICE_1 TRICE32_1 //!< Default parameter bit width for 1 parameter count TRICE is 32, change for a different value.
243 #define TRICE_2 TRICE32_2 //!< Default parameter bit width for 2 parameter count TRICE is 32, change for a different value.
244 #define TRICE_3 TRICE32_3 //!< Default parameter bit width for 3 parameter count TRICE is 32, change for a different value.
245 #define TRICE_4 TRICE32_4 //!< Default parameter bit width for 4 parameter count TRICE is 32, change for a different value.
246 #define TRICE_5 TRICE32_5 //!< Default parameter bit width for 5 parameter count TRICE is 32, change for a different value.
247 #define TRICE_6 TRICE32_6 //!< Default parameter bit width for 6 parameter count TRICE is 32, change for a different value.
248 #define TRICE_7 TRICE32_7 //!< Default parameter bit width for 7 parameter count TRICE is 32, change for a different value.
249 #define TRICE_8 TRICE32_8 //!< Default parameter bit width for 8 parameter count TRICE is 32, change for a different value.
250 #define TRICE_9 TRICE32_9 //!< Default parameter bit width for 9 parameter count TRICE is 32, change for a different value.
251 #define TRICE_10 TRICE32_10 //!< Default parameter bit width for 10 parameter count TRICE is 32, change for a different value.
252 #define TRICE_11 TRICE32_11 //!< Default parameter bit width for 11 parameter count TRICE is 32, change for a different value.
253 #define TRICE_12 TRICE32_12 //!< Default parameter bit width for 12 parameter count TRICE is 32, change for a different value.
254 //
255 //
256 //
```

- Use `-defaultTRICEBitwidth` switch during logging when changing this value.
- The macros `trice8`, `trice16`, `trice32`, `trice64` are usable too, to define the bit width explicit.
  - This leads for the smaller bit widths to less needed space and bandwidth. But when using the default package framing TCOBS, the influence is marginal because of the implicit compression.
- The fastest Trice macro execution is, when MCU bit width matches the macro bit width.
- The implicit TCOBS compression compacts the binary Trice data during the framing.

### 34.4. Many value parameters

- No need to explicitly express the values count.
- Up to 12 values are supported directly. Example:

- `trice( "%p | %04x %04x %04x %04x %04x %04x %04x | %f\n", p, p[0], p[1], p[2], p[3], p[4], p[5], p[6], p[7], p[8], p[9], aFloat(x));`
- To support more than 12 values for each Trice macro, the Trice code on target and host is straightforward extendable up to a total payload of 32764 bytes.
- Each macro can be prolonged with the used parameter count, for example `TRICE8_3` or `TRICE_2` to intense compile time checks.
  - This length code extension can be done automatically using `trice u -addParamCount`. This is not needed anymore:
- The *Trice* tool compares the number of given format specifiers with the written parameters in a precompile step to minimize the risk of runtime errors.
- There is no variadic values scanning during runtime. The C preprocessor does the work.

### 34.5. Floating Point Values

These types are mixable with integer types but need to be covered by converter function.

- *float* types use the `aFloat()` function and need a minimal value bit width of 32, to secure correct data transfer.

- Example:

```
float x = 7.2;
trice("%f", aFloat(x));
```

- *double* types use the `aDouble()` function and need a value bit width of 64, to secure correct data transfer.

- Example:

```
double y = 7.2;
trice64("float %f and double %f", aFloat(x), aDouble(y));
```

- Both functions are simple and fast:

```
// aFloat returns passed float value x as bit pattern in a uint32_t type.
static inline uint32_t aFloat(float x){
 union {
 float f;
 uint32_t u;
 } t;
 t.f = x;
 return t.u;
}

// aDouble returns passed double value x as bit pattern in a uint64_t type.
static inline uint64_t aDouble(double x){
 union {
 double d;
 uint64_t u;
 } t;
 t.d = x;
 return t.u;
}
```

### 34.6. Runtime Generated 0-terminated Strings Transfer with triceS

- The `%s` format specifier is supported by the Trice macro too but needs specific treatment.
- Strings, known at compile time should be a part of a format string to reduce runtime overhead.
- Strings created at runtime, need a special `TRICE_S` (or `triceS`, `TriceS`, `TRiceS`) macro, which accepts exactly one type `%s` format specifier. Generated strings are allowed to a size of 32764 bytes each, if the configured Trice buffer size is sufficient.
  - Example:

```
char s[] = "Hello again!";
triceS("A runtime string %20s\n", s;
```

### 34.7. Runtime Generated counted Strings Transfer with triceN

- It is also possible to transfer a buffer with length n using the **TRICE\_N** (or **triceN**, **TriceN**, **TRiceN**) macro.
- This becomes handy for example, when a possibly not 0-terminated string in FLASH memory needs transmission: **triceN( "msg: FLASH string is %s", addr, 16 );**
- There are also specific macros like **trice32B** or **trice16F**. Please look into **triceCheck.c** for usage or see the following.

### 34.8. Runtime Generated Buffer Transfer with triceB

- A buffer is transmittable with **TRICE\_B** (or **triceB**, **TriceB**, **TRiceB**) and specifying just one format specifier, which is then repeated.
- Example:

```
s = "abcde 12345"; // assume this as runtime generated string
triceS("msg:Show s with triceS: %s\n", s);
len = strlen(s);
triceN("sig:Show s with triceN:%s\n", s, len);
triceB("dbg: %02x\n", s, len); // Show s as colored code sequence in hex code.
triceB("msg: %4d\n", s, len); // Show s as colored code sequence in decimal code.
```

|                  |         |                                    |
|------------------|---------|------------------------------------|
| triceCheck.c: 90 | 1000010 | with TRICE_S:abcde 12345           |
| triceCheck.c: 92 | 1000016 | With TRICE_N:abcde 12345           |
| triceCheck.c: 93 | 1000020 | Len=11:With TRICE_B:               |
| triceCheck.c: 94 | 1000022 | 61 62 63 64 65 20 31 32 33 34 35   |
| triceCheck.c: 96 | 1000027 | 97 98 99 100 101 32 49 50 51 52 53 |

This gives output similar to:

Channel specifier within the **TRICE\_B** format string are supported in Trice versions >= v0.66.0.

If the buffer is not 8 but 16, 32 or 32 bits wide, the macros **TRICE8\_B**, **TRICE16\_B**, **TRICE32\_B** and **TRICE64\_B**, are usable in the same manner.

### 34.9. Remote function call syntax support with triceF

The **TRICE8\_F**, **TRICE16\_F**, **TRICE32\_F**, **TRICE64\_F**, macros expect a string without format specifiers which is usable later as a function call.  
Examples:

```
trice8F("call:FunctionNameW", b8, sizeof(b8) /sizeof(int8_t)); //exp: time: default:
call:FunctionNameW(00)(ff)(fe)(33)(04)(05)(06)(07)(08)(09)(0a)(0b)(00)(ff)(fe)(33)(04)(05)(06)(07)(08)
(09)(0a)(0b)
TRICE16_F("info:FunctionNameX", b16, sizeof(b16)/sizeof(int16_t)); //exp: time: 842,150_450default:
info:FunctionNameX(0000)(ffff)(fffe)(3344)
TRice16F("call:FunctionNameX", b16, sizeof(b16)/sizeof(int16_t)); //exp: time: 842,150_450default:
call:FunctionNameX(0000)(ffff)(fffe)(3344)
Trice16F("call:FunctionNameX", b16, sizeof(b16)/sizeof(int16_t)); //exp: time: 5_654default:
call:FunctionNameX(0000)(ffff)(fffe)(3344)
trice16F("call:FunctionNameX", b16, sizeof(b16)/sizeof(int16_t)); //exp: time: default:
call:FunctionNameX(0000)(ffff)(fffe)(3344)
TRICE32_F("info:FunctionNameY", b32, sizeof(b32)/sizeof(int32_t)); //exp: time: 842,150_450default:
info:FunctionNameY(00000000)(ffffffff)(ffffffe)(33445555)
TRice32F("call:FunctionNameY", b32, sizeof(b32)/sizeof(int32_t)); //exp: time: 842,150_450default:
call:FunctionNameY(00000000)(ffffffff)(ffffffe)(33445555)
Trice32F("call:FunctionNameY", b32, sizeof(b32)/sizeof(int32_t)); //exp: time: 5_654default:
call:FunctionNameY(00000000)(ffffffff)(ffffffe)(33445555)
trice32F("call:FunctionNameY", b32, sizeof(b32)/sizeof(int32_t)); //exp: time: default:
call:FunctionNameY(00000000)(ffffffff)(ffffffe)(33445555)
TRICE64_F("info:FunctionNameZ", b64, sizeof(b64)/sizeof(int64_t)); //exp: time: 842,150_450default:
info:FunctionNameZ(0000000000000000)(ffffffffffff)(ffffffffff)(3344555566666666)
TRice64F("call:FunctionNameZ", b64, sizeof(b64)/sizeof(int64_t)); //exp: time: 842,150_450default:
call:FunctionNameZ(0000000000000000)(ffffffffffff)(ffffffffff)(3344555566666666)
Trice64F("call:FunctionNameZ", b64, sizeof(b64)/sizeof(int64_t)); //exp: time: 5_654default:
call:FunctionNameZ(0000000000000000)(ffffffffffff)(ffffffffff)(3344555566666666)
trice64F("call:FunctionNameZ", b64, sizeof(b64)/sizeof(int64_t)); //exp: time: default:
call:FunctionNameZ(0000000000000000)(ffffffffffff)(ffffffffff)(3344555566666666)
```

The Trice tool displays the parameter buffer in the shown manner. There is a [FunctionPointerList Generator](#), which generates mainly a function pointer list with associated IDs. This list can get part of the source code of a remote device. Then, when receiving a Trice message, the remote device can execute the assigned function call using the transferred parameters. This way several devices can communicate in an easy and reliable way.

With `#define TRICE_F TRICE16_F` in the project specific `triceConfig.h` file the user can specify which should be the bitwidth (16 in this example) for `triceF` macros. The default value is 8.

**Hint:** If you add for example "rpc" as tag and call `trice log -ban "rpc"`, the Trice tool will not display the RPC Trices, but all others. That could be helpful, if you have frequent RPCs and do not wish to spoil your log output with them.

- Future extensions are possible:

- `triceD( "dump:32", addr, 160 );` -> The Trice tool dumps in 32 byte rows.
- An appropriate syntax is needed.

### 34.10. Extended format specifier possibilities

- Because the format string is interpreted by the Trice tool written in **Go**, the **Go** capabilities partial usable.

#### 34.10.1. Trice format specifier

- The Trice macros are used in **C** code.
- The format strings are interpreted by the Trice tool, which is written in **Go**.
- The **C** and **Go** format specifier are not equal but similar.
- Therefore, a Trice adaption is internally performed.

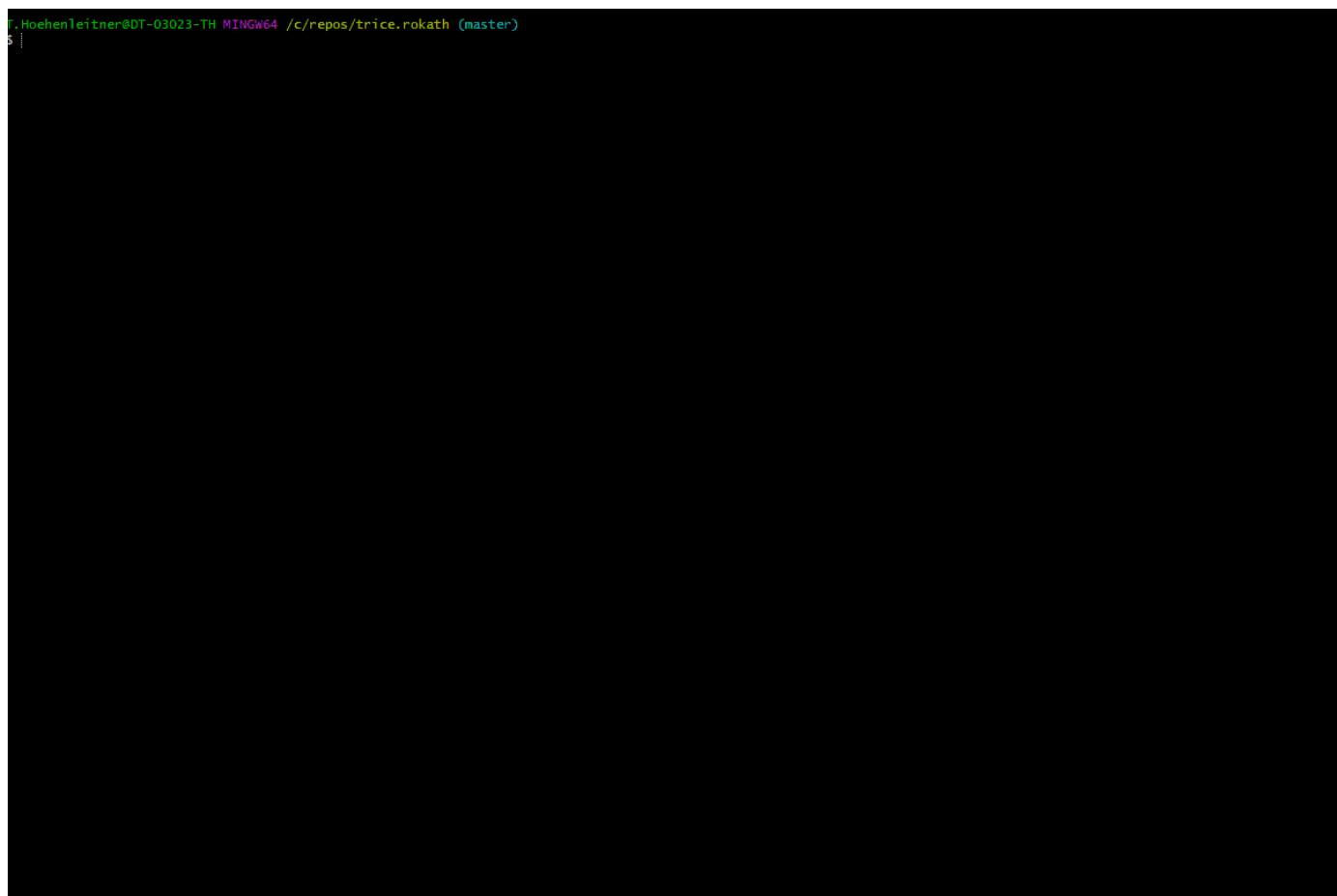
#### 34.10.2. Overview Table

| Format Specifier Type                              | C | Go | T | (T =Trice)   remark                                                     |
|----------------------------------------------------|---|----|---|-------------------------------------------------------------------------|
| signed decimal integer                             | d | d  | d | Supported.                                                              |
| unsigned decimal integer                           | u | -  | u | The Trice tool changes %u into %d and treats value as unsigned.         |
| signed decimal integer                             | i | d  | i | The Trice tool changes %i into %d and treats value as signed.           |
| signed octal integer                               | - | o  | o | With <code>trice log -unsigned=false</code> value is treated as signed. |
| unsigned octal integer                             | o | -  | o | With <code>trice log</code> value is treated as unsigned.               |
| signed octal integer with 0o prefix                | - | O  | O | With <code>trice log -unsigned=false</code> value is treated as signed. |
| unsigned octal integer with 0o prefix              | - | -  | O | With <code>trice log</code> value is treated as unsigned.               |
| signed hexadecimal integer lowercase               | - | x  | x | With <code>trice log -unsigned=false</code> value is treated as signed. |
| unsigned hexadecimal integer lowercase             | x | -  | x | With <code>trice log</code> value is treated as unsigned.               |
| signed hexadecimal integer uppercase               | - | X  | X | With <code>trice log -unsigned=false</code> value is treated as signed. |
| unsigned hexadecimal integer uppercase             | X | -  | X | With <code>trice log</code> value is treated as unsigned.               |
| signed binary integer                              | - | b  | b | With <code>trice log -unsigned=false</code> value is treated as signed. |
| unsigned binary integer                            | - | -  | b | With <code>trice log</code> value is treated as unsigned.               |
| decimal floating point, lowercase                  | f | f  | f | <code>aFloat(value) aDouble(value)</code>                               |
| decimal floating point, uppercase                  | - | F  | F | <code>aFloat(value) aDouble(value)</code>                               |
| scientific notation (mantissa/exponent), lowercase | e | e  | e | <code>aFloat(value) aDouble(value)</code>                               |
| scientific notation (mantissa/exponent), uppercase | E | E  | E | <code>aFloat(value) aDouble(value)</code>                               |
| the shortest representation of %e or %f            | g | g  | g | <code>aFloat(value) aDouble(value)</code>                               |
| the shortest representation of %E or %F            | G | G  | G | <code>aFloat(value) aDouble(value)</code>                               |

| FormatSpecifier Type                                            | C | Go | T | (T =Trice)   remark                                                           |
|-----------------------------------------------------------------|---|----|---|-------------------------------------------------------------------------------|
| a character as byte                                             | c | -  | c | Value can contain ASCII character.                                            |
| a character represented by the corresponding Unicode code point | c | c  | c | Value can contain UTF-8 characters if the C-File is edited in UTF-8 format.   |
| a quoted character                                              | - | q  | q | Supported.                                                                    |
| the word true or false                                          | - | t  | t | Supported.                                                                    |
| a string                                                        | s | s  | s | Use <code>triceS</code> macro with one and only one runtime generated string. |
| pointer address                                                 | p | p  | p | Supported.                                                                    |
| a double %% prints a single %                                   | % | %  | % | Supported.                                                                    |
| Unicode escape sequence                                         | - | U  | - | <b>Not supported.</b>                                                         |
| value in default format                                         | - | v  | - | <b>Not supported.</b>                                                         |
| Go-syntax representation of the value                           | - | #v | - | <b>Not supported.</b>                                                         |
| a Go-syntax representation of the type of the value             | - | T  | - | <b>Not supported.</b>                                                         |
| nothing printed                                                 | n | -  | - | <b>Not supported.</b>                                                         |

- Long story short: Use the `-unsigned=false` switch when you like to see hex numbers and the like as signed values.
- Look in `triceCheck.c` for example code producing this:

```
F.Hoehenleitner@DT-03023-TH MINGW64 /c/repos/trice.rokath (master)
5 |
```



### 34.11. UTF-8 Support

This is gratis, if you edit your source files containing the format strings in UTF-8:

```
Jan 2 17:37:43.765791 COM11: triceCheck.c: 731 84800049 62936 TRICE64_1 double 518.0547492508867 (%G), aDouble(y)
Jan 2 17:37:43.765791 COM11: main.c: 157 84800051 40126 MSG: STOP select = 23, TriceDepthMax =1832
Jan 2 17:37:43.765791 COM11: main.c: 164 84800053 33395 84800052 µs - ReadUs() lasts 35 ticks
Jan 2 17:37:43.953268 COM11: main.c: 155 85000004 50543 MSG: START select = 24, TriceDepthMax =1832
Jan 2 17:37:43.953268 COM11: triceCheck.c: 734 85000006 45826 negative float & double
Jan 2 17:37:43.953268 COM11: triceCheck.c: 735 85000007 55265 TRICE float -1.089608e+03 (%e)
```

The target does not even "know" about that, because it gets only the Trice IDs.

### 34.12. Switch the language without changing a bit inside the target code

Once the `til.json` list is done the user can translate it in any language and exchanging the list switches to another language.

### 34.13. Format tags prototype specifier examples

This syntax is supported: `%[flags] [width] [.precision] [length]`

- Because the interpretation is done inside the Trice tool written in Go these all should work:
  - `%-d`
  - `%064b`
  - `%+9.3f`
  - `%+#012.12g`
  - `%+'#012.12E`
  - `%e`
  - `%9.f`

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## 35. Development Environment Setup

- Trice is usable with any C-compiler for any processor type, bit width and endianness. The example projects here are STM32 ones but illustrate how to setup Trice.
- The `examples` folder contains some instrumented example projects together with bare counterparts. Comparing a bare project with its instrumented counterpart gives a quick overview what needs to be done to get started.

### 35.1. Common Information

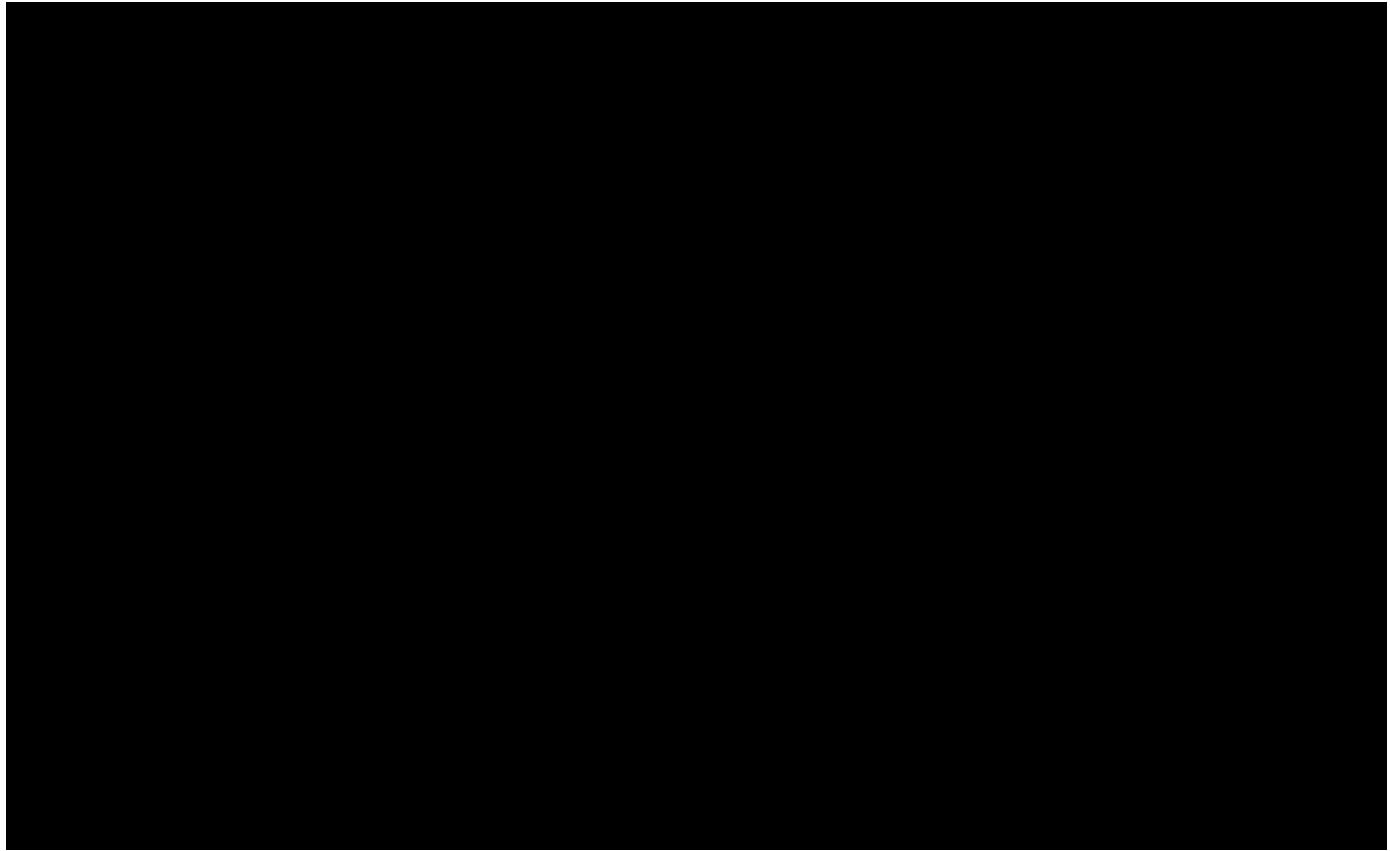
- All used tools are **Open Source** (despite the [ARM-Keil µVision IDE](#), for new projects vsCode is a better choice).
- All provided information is just as example and needs adaption to your needs.
- There is no need to setup the environment in the given order.

### 35.2. Important to know

The [ARM-Keil µVision IDE](#) does sometimes not recognize external file modifications. That means for example: After editing `main.c` by adding a `trice( "Hi!\n" )` and executing `trice insert` as pre-compile step it could happen, that an updated `trice( id(12345), "Hi!\n" )` was inserted and correct compiled but the update in `main.c` is not shown. Simply close and reopen `main.c` before editing again. This seems to be a [ARM-Keil µVision IDE](#) "feature" or be caused Windows not signaling a file change.

### 35.3. Animation

(The trice IDs occur just during the compilation.)



### 35.4. Setup Linux PC - Example with Debian12 - KDE Desktop

#### 35.4.1. Basic setup

- Add yourself to the sudo group:

```
su
apt install sudo
adduser <your_user_name> sudo
exit
```

- Logout and login.
- Install and verify:

```
groups
sudo apt update
sudo apt upgrade
sudo apt install build-essential
make --version
gcc --version
git --version
git config --global user.email "you@example.com"
git config --global user.name "Your Name"
```

#### 35.4.2. Github

- Create github account.
- Create ssh pair:

```
ssh-keygen -t ed25519
```

- Add ssh key to your github account.

- Clone Trice repository:

```
cd ~
mkdir repos
cd repos
git clone git@github.com:rokath/trice.git
```

### 35.4.3. vsCode

- Download vsCode from <https://code.visualstudio.com/download>.
- Install vsCode (adapt to downloaded version) and start it inside the Trice folder:

```
sudo apt update
sudo apt upgrade
sudo apt install ~/Downloads/code_1.96.2-1734607745_amd64.deb
code .
```

### 35.4.4. Go

- Download the **Go** language from <https://go.dev/doc/install> and install:

```
cd ~/Downloads
sudo rm -rf /usr/local/go && sudo tar -C /usr/local -xzf go1.23.4.linux-amd64.tar.gz
```

Extend PATH variable with `/usr/local/go/bin:~/go/bin` for example by adding a file like `/etc/profile.d/gopath.sh`:

```
SU
sudo echo export PATH='$PATH':/usr/local/go/bin:/home/<your_user_name>/go/bin >
/etc/profile.d/gopath.sh
exit
```

- Logout, login and compile Trice:

```
th@P51-DebianKDE:~/repos$ go version
go version go1.23.4 linux/amd64
th@P51-DebianKDE:~/repos$ cd trice
th@P51-DebianKDE:~/repos/trice$ go install ./cmd/...
go: downloading github.com/spf13/afero v1.9.5
go: downloading github.com/kr/pretty v0.1.0
go: downloading go.bug.st/serial v1.6.0
go: downloading github.com/mgutz/ansi v0.0.0-20200706080929-d51e80ef957d
go: downloading github.com/rokath/cobs v0.0.0-20230425030040-4ebbe9b903b9
go: downloading github.com/rokath/tcobs v0.9.1
go: downloading golang.org/x/crypto v0.31.0
go: downloading github.com/fsnotify/fsnotify v1.6.0
go: downloading github.com/pkg/errors v0.9.1
go: downloading golang.org/x/sys v0.28.0
go: downloading golang.org/x/text v0.21.0
go: downloading github.com/kr/text v0.1.0
go: downloading github.com/mattn/go-colorable v0.1.13
go: downloading github.com/creack/goselect v0.1.2
go: downloading github.com/mattn/go-isatty v0.0.19
th@P51-DebianKDE:~/repos/trice$ trice version
version=devel, built 2025-01-04 16:29:30.51921408 +0100 CET
th@P51-DebianKDE:~/repos/trice$ go test ./...
go: downloading github.com/tj/assert v0.0.3
go: downloading github.com/stretchr/testify v1.8.4
go: downloading github.com/udhos/equalfile v0.3.0
go: downloading github.com/pmezard/go-difflib v1.0.0
go: downloading gopkg.in/yaml.v3 v3.0.1
```

```

go: downloading github.com/davecgh/go-spew v1.1.1
? github.com/rokath/trice/internal/do [no test files]
? github.com/rokath/trice/internal/translator [no test files]
? github.com/rokath/trice/pkg/ant [no test files]
ok github.com/rokath/trice/cmd/trice 1.014s
ok github.com/rokath/trice/internal/args 0.009s
ok github.com/rokath/trice/internal/charDecoder 0.005s
ok github.com/rokath/trice/internal/com 0.005s
ok github.com/rokath/trice/internal/decoder 0.005s
ok github.com/rokath/trice/internal/dumpDecoder 0.006s
ok github.com/rokath/trice/internal/emitter 0.006s
ok github.com/rokath/trice/internal/id 2.744s
ok github.com/rokath/trice/internal/keybcmnd 0.006s
ok github.com/rokath/trice/internal/link 0.006s
ok github.com/rokath/trice/internal/receiver 0.007s
ok github.com/rokath/trice/internal/trexDecoder 0.008s
ok github.com/rokath/trice/pkg/cipher 0.006s
ok github.com/rokath/trice/pkg/endian 0.002s
ok github.com/rokath/trice/pkg/msg 0.005s
ok github.com/rokath/trice/pkg/tst 0.003s
th@P51-DebianKDE:~/repos/trice$
th@P51-DebianKDE:~/repos/trice$ gcc --version
gcc (Debian 12.2.0-14) 12.2.0
Copyright (C) 2022 Free Software Foundation, Inc.
This is free software; see the source for copying conditions. There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.

```

```

th@P51-DebianKDE:~/repos/trice$./testAll.sh
Sa 4. Jan 16:33:57 CET 2025
This can take several minutes ...
? github.com/rokath/trice/internal/do [no test files]
ok github.com/rokath/trice/cmd/trice 1.013s
ok github.com/rokath/trice/internal/args 0.007s
ok github.com/rokath/trice/internal/charDecoder 0.004s
ok github.com/rokath/trice/internal/com 0.004s
ok github.com/rokath/trice/internal/decoder 0.003s
ok github.com/rokath/trice/internal/dumpDecoder 0.004s
ok github.com/rokath/trice/internal/emitter 0.003s
? github.com/rokath/trice/internal/translator [no test files]
? github.com/rokath/trice/pkg/ant [no test files]
ok github.com/rokath/trice/internal/id 2.742s
ok github.com/rokath/trice/internal/keybcmnd 0.004s
ok github.com/rokath/trice/internal/link 0.004s
ok github.com/rokath/trice/internal/receiver 0.005s
ok github.com/rokath/trice/internal/trexDecoder 0.005s
ok github.com/rokath/trice/pkg/cipher 0.004s
ok github.com/rokath/trice/pkg/endian 0.002s
ok github.com/rokath/trice/pkg/msg 0.004s
ok github.com/rokath/trice/pkg/tst 0.004s
ok github.com/rokath/trice/_test/be_dblB_de_tcobs_ua 144.000s
ok github.com/rokath/trice/_test/be_staticB_di_xtea_cobs_rtt32 143.927s
ok github.com/rokath/trice/_test/dblB_de_cobs_ua 144.006s
ok github.com/rokath/trice/_test/dblB_de_multi_cobs_ua 143.824s
ok github.com/rokath/trice/_test/dblB_de_multi_nopf_ua 144.087s
ok github.com/rokath/trice/_test/dblB_de_multi_tcobs_ua 144.100s
ok github.com/rokath/trice/_test/dblB_de_multi_xtea_cobs_ua 143.928s
ok github.com/rokath/trice/_test/dblB_de_multi_xtea_tcobs_ua 144.034s
ok github.com/rokath/trice/_test/dblB_de_nopf_ua 142.399s
ok github.com/rokath/trice/_test/dblB_de_tcobs_ua 142.520s
ok github.com/rokath/trice/_test/dblB_de_xtea_cobs_ua 142.526s
ok github.com/rokath/trice/_test/dblB_de_xtea_tcobs_ua 142.246s
ok github.com/rokath/trice/_test/dblB_di_nopf_rtt32_de_cobs_ua 281.643s
ok github.com/rokath/trice/_test/dblB_di_nopf_rtt32_de_multi_cobs_ua 281.201s
ok github.com/rokath/trice/_test/dblB_di_nopf_rtt32_de_multi_tcobs_ua 281.518s
ok github.com/rokath/trice/_test/dblB_di_nopf_rtt32_de_tcobs_ua 281.536s
ok github.com/rokath/trice/_test/dblB_di_nopf_rtt32_de_xtea_cobs_ua 279.814s
ok github.com/rokath/trice/_test/dblB_di_nopf_rtt8_de_cobs_ua 280.173s
ok github.com/rokath/trice/_test/dblB_di_nopf_rtt8_de_multi_cobs_ua 280.095s
ok github.com/rokath/trice/_test/dblB_di_nopf_rtt8_de_multi_tcobs_ua 279.693s
ok github.com/rokath/trice/_test/dblB_di_nopf_rtt8_de_tcobs_ua 291.037s
ok github.com/rokath/trice/_test/ringB_de_cobs_ua 140.861s

```

```

ok github.com/rokath/trice/_test/ringB_de_multi_tcobs_ua 140.802s
ok github.com/rokath/trice/_test/ringB_de_multi_xtea_cobs_ua 141.037s
ok github.com/rokath/trice/_test/ringB_de_multi_xtea_tcobs_ua 149.046s
ok github.com/rokath/trice/_test/ringB_de_nopf_ua 149.114s
ok github.com/rokath/trice/_test/ringB_de_tcobs_ua 149.121s
ok github.com/rokath/trice/_test/ringB_de_xtea_cobs_ua 149.089s
ok github.com/rokath/trice/_test/ringB_de_xtea_tcobs_ua 149.164s
ok github.com/rokath/trice/_test/ringB_di_cobs_rtt32_de_tcobs_ua 288.603s
ok github.com/rokath/trice/_test/ringB_di_cobs_rtt8_de_tcobs_ua 288.569s
ok github.com/rokath/trice/_test/ringB_di_nopf_rtt32_de_tcobs_ua 278.409s
ok github.com/rokath/trice/_test/ringB_di_nopf_rtt32_de_xtea_cobs_ua 278.493s
ok github.com/rokath/trice/_test/ringB_di_nopf_rtt8_de_tcobs_ua 278.301s
ok github.com/rokath/trice/_test/ringB_di_tcobs_rtt32_de_tcobs_ua 278.462s
ok github.com/rokath/trice/_test/ringB_di_xtea_cobs_rtt32_de_xtea_cobs_ua 278.590s
ok github.com/rokath/trice/_test/special_for_debug 0.129s
ok github.com/rokath/trice/_test/special_protect_dblB_de_tcobs_ua 0.130s
ok github.com/rokath/trice/_test/stackB_di_nopf_aux32 139.984s
ok github.com/rokath/trice/_test/stackB_di_nopf_aux8 139.358s
ok github.com/rokath/trice/_test/stackB_di_nopf_rtt32 139.366s
ok github.com/rokath/trice/_test/stackB_di_nopf_rtt8 143.107s
ok github.com/rokath/trice/_test/stackB_di_xtea_cobs_rtt8 141.896s
ok github.com/rokath/trice/_test/staticB_di_nopf_aux32 141.398s
ok github.com/rokath/trice/_test/staticB_di_nopf_aux8 141.677s
ok github.com/rokath/trice/_test/staticB_di_nopf_rtt32 141.779s
ok github.com/rokath/trice/_test/staticB_di_nopf_rtt8 141.609s
ok github.com/rokath/trice/_test/staticB_di_tcobs_rtt32 141.487s
ok github.com/rokath/trice/_test/staticB_di_tcobs_rtt8 141.559s
ok github.com/rokath/trice/_test/staticB_di_xtea_cobs_rtt32 139.048s
Script run 1300 seconds.
th@P51-DebianKDE:~/repos/trice$
```

#### 35.4.5. Gitkraken (or other GUI for git)

- Gitkraken download from <https://www.gitkraken.com/download> and Install:

```
mv ./gitkraken-amd64.deb /tmp; sudo apt install /tmp/gitkraken-amd64.deb
```

#### 35.4.6. arm-none-eabi toolchain (or other target system compiler)

```

sudo apt install gcc-arm-none-eabi
sudo apt install binutils-arm-none-eabi
sudo apt install gdb-arm-none-eabi
sudo apt install openocd
arm-none-eabi-gcc --version
arm-none-eabi-gcc (15:12.2.rel1-1) 12.2.1 20221205
Copyright (C) 2022 Free Software Foundation, Inc.
This is free software; see the source for copying conditions. There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.
```

- See installed toolchain:

```

ls -l /usr/bin/ | grep arm-none-eabi
-rwxr-xr-x 1 root root 1033504 Feb 28 2023 arm-none-eabi-addr2line
-rwxr-xr-x 2 root root 1066088 Feb 28 2023 arm-none-eabi-ar
-rwxr-xr-x 2 root root 2095024 Feb 28 2023 arm-none-eabi-as
-rwxr-xr-x 2 root root 1514496 Dec 22 2022 arm-none-eabi-c++
-rwxr-xr-x 1 root root 1032992 Feb 28 2023 arm-none-eabi-c++filt
-rwxr-xr-x 1 root root 1514496 Dec 22 2022 arm-none-eabi-cpp
-rwxr-xr-x 1 root root 43640 Feb 28 2023 arm-none-eabi-elfedit
-rwxr-xr-x 2 root root 1514496 Dec 22 2022 arm-none-eabi-g++
-rwxr-xr-x 2 root root 1514496 Dec 22 2022 arm-none-eabi-gcc
-rwxr-xr-x 2 root root 1514496 Dec 22 2022 arm-none-eabi-gcc-12.2.1
-rwxr-xr-x 1 root root 35376 Dec 22 2022 arm-none-eabi-gcc-ar
-rwxr-xr-x 1 root root 35376 Dec 22 2022 arm-none-eabi-gcc-nm
```

```
-rwxr-xr-x 1 root root 35376 Dec 22 2022 arm-none-eabi-gcc-ranlib
-rw-rxr-xr-x 1 root root 749664 Dec 22 2022 arm-none-eabi-gcov
-rw-rxr-xr-x 1 root root 585688 Dec 22 2022 arm-none-eabi-gcov-dump
-rw-rxr-xr-x 1 root root 610328 Dec 22 2022 arm-none-eabi-gcov-tool
-rw-rxr-xr-x 1 root root 1104256 Feb 28 2023 arm-none-eabi-gprof
-rw-rxr-xr-x 4 root root 1709968 Feb 28 2023 arm-none-eabi-ld
-rw-rxr-xr-x 4 root root 1709968 Feb 28 2023 arm-none-eabi-ld.bfd
-rw-rxr-xr-x 1 root root 24982344 Dec 22 2022 arm-none-eabi-lto-dump
-rw-rxr-xr-x 2 root root 1054720 Feb 28 2023 arm-none-eabi-nm
-rw-rxr-xr-x 2 root root 1180744 Feb 28 2023 arm-none-eabi-objcopy
-rw-rxr-xr-x 2 root root 1867744 Feb 28 2023 arm-none-eabi-objdump
-rw-rxr-xr-x 2 root root 1066120 Feb 28 2023 arm-none-eabi-ranlib
-rw-rxr-xr-x 2 root root 973400 Feb 28 2023 arm-none-eabi-readelf
-rw-rxr-xr-x 1 root root 1033280 Feb 28 2023 arm-none-eabi-size
-rw-rxr-xr-x 1 root root 1037504 Feb 28 2023 arm-none-eabi-strings
-rw-rxr-xr-x 2 root root 1180744 Feb 28 2023 arm-none-eabi-strip
```

- For some reason `sudo apt install gdb-arm-none-eabi` gives the message **Note, selecting 'gdb-multiarch' instead of 'gdb-arm-none-eabi'** and `arm-none-eabi-gdb` is not installed afterwards.
- To try the newest version, download it from <https://developer.arm.com/downloads/-/arm-gnu-toolchain-downloads>.

- Setup:
  - Unpack and extend \$PATH at the beginning:

```
cd ~/Downloads
tar xf arm-gnu-toolchain-14.2.rel1-x86_64-arm-none-eabi.tar.xz
su
echo export PATH=/home/th/Downloads/arm-gnu-toolchain-14.2.rel1-x86_64-arm-none-
eabi/bin:'$PATH' > /etc/profile.d/arm14.2path.sh
exit
```

- Logout and login

```
arm-none-eabi-gcc --version
arm-none-eabi-gcc (Arm GNU Toolchain 14.2.Rel1 (Build arm-14.52)) 14.2.1 20241119
Copyright (C) 2024 Free Software Foundation, Inc.
This is free software; see the source for copying conditions. There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.
```

```
arm-none-eabi-gdb --version
GNU gdb (Arm GNU Toolchain 14.2.Rel1 (Build arm-14.52)) 15.2.90.20241130-git
Copyright (C) 2024 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.
```

- Remove: Delete `/etc/profile.d/arm14.2path.sh` and `~/Downloads/arm-gnu-toolchain-14.2.rel1-x86_64-arm-none-eabi`

#### 35.4.7. J-Link (if needed)

- Download and install from <https://www.segger.com/downloads/jlink/#J-LinkSoftwareAndDocumentationPack>

```
sudo apt install ~/Downloads/JLink_Linux_V812_x86_64.deb
```

- Logout & login & check:

```
th@P51-DebianKDE:~/Downloads$ JLinkRTTLogger -?
SEGGER J-Link RTT Logger
```

```

Compiled Dec 18 2024 15:48:21
(c) 2016–2017 SEGGER Microcontroller GmbH, www.segger.com
 Solutions for real time microcontroller applications

Default logfile path: /home/th/.config/SEGGER

Available options:
-Device <devicename>
-If <ifname>
-Speed <speed>
-USB <SN>
-IP <SN>
-RTTAddress <RTTAddress>
-RTTSearchRanges "<Rangestart> <RangeSize>[, <Range1Start> <Range1Size>, ...]"
"-RTTChannel <RTTChannel>
-JLinkScriptFile <PathToScript>
<OutFilename>

Shutting down... Done.th@P51-DebianKDE:~/Downloads$
```

### 35.4.8. Beyond Compare (if no other diff tool)

- Download and install from <https://www.scootersoftware.com>

## 35.5. Setup Windows PC Example

Setting up a PC is for Linux mostly straightforward but Windows PCs are more problematic. The steps shown here are just one example.

- Create folder **repos** in your home directory.
  - Clone all repositories here.
- Create **C:\bin** folder.
  - When installing toolchains, put them here then and avoid spaces in created paths.
- Add **C:\bin** to PATH variable at the beginning.
  - This allows to copy tools like **trice.exe** simply into **C:\bin**.
- Install "Git for windows" from <https://git-scm.com/downloads> to get the neat git bash.
  - Select the Standalone Installer. This gives you useful context menu entries in the Windows explorer.
- BTW: For managing git repositories I like <https://www.gitkraken.com/>. Its free of charge for open source programs.
- Install VS-Code
  - This is my favorite editor with many optional Add-Ons. It is used for debugging as well.
- Install Go if you wish to compile Go programs.
  - **go test ./...** should succeed in a terminal window.
  - When GCC is not installed you get some strange errors with **TestAll.sh**:

```

ms@PaulPCWin11 MINGW64 ~/repos/trice (devel)
$./testAll.sh
Fri Jan 10 11:19:39 WEST 2025
This can take several minutes ...

...
ok github.com/rokath/trice/pkg/tst 0.601s
github.com/rokath/trice/_test/dblB_de_cobs_ua
[github.com/rokath/trice/_test/dblB_de_cobs_ua.test]
dblB_de_cobs_ua\cgo_test.go:20:110: undefined: triceDir
dblB_de_cobs_ua\cgo_test.go:24:2: undefined: triceLogTest
dblB_de_cobs_ua\cgo_test.go:24:28: undefined: testLines
github.com/rokath/trice/_test/dblB_de_tcobs_ua
[github.com/rokath/trice/_test/dblB_de_tcobs_ua.test]
dblB_de_tcobs_ua\cgo_test.go:20:92: undefined: triceDir
dblB_de_tcobs_ua\cgo_test.go:24:2: undefined: triceLogTest
dblB_de_tcobs_ua\cgo_test.go:24:28: undefined: testLines
```

- Download and install latest GCC then, from <https://winlibs.com> for example.
  - Extract to **C:\bin\mingw64** and extend PATH with **C:\bin\mingw64\bin**

- Open terminal and execute `gcc --version` to check success.
- Setup J-Link if you use this debug probe as hardware or software (see below).
  - Install SEGGER J-Link Software and Documentation Pack
- Install Make for Windows and add its installation bin folder location to the PATH variable.

### 35.5.1. Setup Trice

- from inside folder `repos` clone trice repo with `git clone https://github.com/rokath/trice.git`.
- Run `go install ./cmd/trice/...` from folder `repos/trice`.

OR

- Download the latest release archive and extract.
- Put trice binary into C:\bin.
- Put trice/src into `repos` if you want access the trice library code from several projects and have it only once.
  - Alternatively copy it into your project.

### 35.5.2. Setup ARM Environment Example

#### Install make

- Fast lane: Go to <https://sourceforge.net/projects/ezwinports/files/>, download and extract `make-4.4.1-without-guile-w32-bin.zip`. Put the `make.exe` file somewhere in your \$PATH.
- OR open the Windows Powershell and:

```
ms@PaulPCWin11 MINGW64 ~/repos/trice/examples (devel)
$ winget install ezwinports.make
The `msstore` source requires that you view the following agreements before using.
Terms of Transaction: https://aka.ms/microsoft-store-terms-of-transaction
The source requires the current machine's 2-letter geographic region to be sent to the backend service
to function properly (ex. "US").

Do you agree to all the source agreements terms?
[Y] Yes [N] No: Y
Found ezwinports: make [ezwinports.make] Version 4.4.1
This application is licensed to you by its owner.
Microsoft is not responsible for, nor does it grant any licenses to, third-party packages.
Downloading https://downloads.sourceforge.net/project/ezwinports/make-4.4.1-without-guile-w32-bin.zip
[██████████] 383 KB / 383 KB
Successfully verified installer hash
Extracting archive...
Successfully extracted archive
Starting package install...
Path environment variable modified; restart your shell to use the new value.
Command line alias added: "make"
Successfully installed

ms@PaulPCWin11 MINGW64 ~/repos/trice/examples (devel)
```

- Check:

```
$ make --version
GNU Make 4.4.1
Built for Windows32
Copyright (C) 1988-2023 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <https://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.
```

#### Install ARM GCC

- Uninstall existing ARM GCC compilers optionally.
- Check if \$PATH is clean.

- In fact you can leave it as it is.
- Check if `C_INCLUDE_PATH` is not defined.
  - It would cause issues performing Go tests with CGO.
  - The environment variable `C_INCLUDE_PATH` is needed by Clang, but is set temporarily inside the Makefile.
- Open a console.
  - `which arm-none-eabi-gcc` should return `no arm-none-eabi-gcc` if no legacy compilers installed.
- Download latest version from <https://developer.arm.com/downloads/-/arm-gnu-toolchain-downloads>.
- Install exactly into `C:\bin\ArmGNUToolchain` and add `C:\bin\ArmGNUToolchain\bin` to the **beginning** of the path variable.
  - The path is temporarily extendable inside the manually edited Makefiles as well, but for debugging the Windows path is used directly.
  - The path is used directly also in generated Makefiles.
  - Extending the path variable at the beginning avoids accidentally usage of installed legacy compilers with the same name.
  - To use exactly `C:\bin\ArmGNUToolchain` as install location allows a more easy project collaboration.
  - Check path:

```
$ echo $PATH | tr : '\n'
...
/c/bin
/c/bin/ArmGNUToolchain/bin
/c/bin/mingw64/bin
/c/Program Files/Go/bin
/c/Users/ms/go/bin
/c/Users/ms/AppData/Local/Microsoft/WinGet/Packages/ezwinports.make_Microsoft.Winget.Source_8wekyb
3d8bbwe/bin
...
```

## MacOS

- In terminal `brew install arm-none-eabi-gcc`
- Restart terminal
- In terminal `arm-none-eabi-gcc --version` delivers `arm-none-eabi-gcc (GCC) 14.2.0`
- In terminal `brew install arm-none-eabi-clang`
- Restart terminal
- In terminal `clang -target arm-none-eabi --version` delivers:

```
Apple clang version 15.0.0 (clang-1500.3.9.4)
Target: arm-none-unknown-eabi
Thread model: posix
InstalledDir: /Library/Developer/CommandLineTools/usr/bin
```

- In terminal `brew install arm-none-eabi-gdb`
- In terminal `brew install --cask gcc-arm-embedded`

## Install ARM Clang (optional)

With the ARM Clang you get quicker compilation runs and smaller images.

- You need to install ARM GCC as well to use ARM Clang.
  - ARM Clang uses the GCC libraries. For that it looks for `C_INCLUDE_PATH`.
  - ARM Clang uses the GCC debugger. For that it looks into the Windows path variable directly.
- Uninstall existing ARM clang compilers or make sure they are hidden.
- Check if `$PATH` is clean.
  - In fact you can leave it as it is.
- Check if `C_INCLUDE_PATH` is not defined.
  - It would cause issues performing Go tests with CGO.
- Open a console.
  - `which clang` should return `no clang`.
  - If you have other clang compilers installed, do not touch them.
- Download latest version from <https://github.com/llvm/llvm-project/releases>.
- Install exactly into `C:\bin\ArmClang` and do **not** add it to path variable.
  - The path is extended temporarily inside the Makefile for the compiler run.

**Check Project Makefile (if it already exists)**

- The Makefile should start with these lines:

```
Put ARM Clang first in path temporary to avoid compiler variants issues.
export PATH := C:\bin\ArmClang\bin:${PATH}

ARM Clang uses the ARM GNU toolchain libraries and finds them over C_INCLUDE_PATH.
export C_INCLUDE_PATH := C:\bin\ArmGNUToolchain\arm-none-eabi\include
```

The **C:\bin\ArmGNUToolchain\bin**: is in fact not needed, because it must be in the path anyway for debugging.

- make version** should give output like that:

```
$ make version
/c/bin/ArmGNUToolchain/bin/arm-none-eabi-gcc
arm-none-eabi-gcc (Arm GNU Toolchain 12.3.Rel1 (Build arm-12.35)) 12.3.1 20230626
Copyright (C) 2022 Free Software Foundation, Inc.
This is free software; see the source for copying conditions. There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.

/c/bin/ArmClang/bin/clang
clang version 17.0.0
Target: x86_64-pc-windows-msvc
Thread model: posix
InstalledDir: C:\bin\ArmClang\bin
```

The paths must match with the installation locations.

**35.5.3. Setup STM32****Generate Base Project**

- Install and start STM32CubeMX code generator.
- Board-Selector -> STM32G0B1KE or STM32L432KC` or ...
- (Auto-)Initialize with default values.
- Clock-Generation -> Change PLL \*N from "X 16" to "X 32" to get 64 MHz clocks.
  - Running at max clock speed and using **WFE** instructions in wait loops is slightly more energy efficient.
- Project Manager
  - Project
    - Set Project Name
    - Select Project Location
    - Toolchain / IDE -> Select Makefile
  - Code Generator
    - Select "Copy only the necessary library files".
  - Advanced Settings
    - Switch from HAL to LL at least for UART
- Generate Code as Makefile project

**Update NUCLEO Onboard Debugger (other ST evaluation boards too)**

(<https://www.st.com/en/development-tools/stsw-link007.html>)

This step is recommended before re-flashing with the J-Link onboard debugger software.

- Connect STM evaluation board over USB
- Start ST-Link Upgrade (trice\third\_party\st.com or look for a newer version at STM.).
  - Device Connect
  - Upgrade Firmware (select version **with** mass storage option)
    - Selecting the other option, would not allow to update with the SEGGER STLinkReflash tool.
  - Close

**35.5.4. Setup Onboard J-Link on NUCLEO (other ST evaluation boards too)**

(<https://www.segger.com/products/debug-probes/j-link/models/other-j-links/st-link-on-board/>)

Using the J-Link onboard debugger software allows parallel debugging and RTT usage.

Unfortunately this is not possible with v3 onboard debugger hardware! But you can use a J-Link hardware instead. Also it is possible to use a v2 onboard debugger from a different evaluation board or a "Bluepill" Development Board Module with ARM Cortex M3 processor".

- Start STLinkReflash (trice\third\_party\segger.com)
  - Accept and Accept
  - 1: Upgrade to J-Link
  - 0: Quit
- Download, extract & start [https://github.com/rokath/trice/blob/master/third\\_party/segger.com/STLinkReflash\\_190812.zip](https://github.com/rokath/trice/blob/master/third_party/segger.com/STLinkReflash_190812.zip)
  - Re-Flash onboard debugger.
    - You can undo this step anytime.

### 35.5.5. Setup VS-Code

- Start VS Code
  - Install Go rich language support if you want to use Go as well (not needed for ARM debugging).
  - Install "Cortex Debug" extension.
  - Open the generated project directory.
  - Click on Run and Debug.
    - Click Generate launch.json and select "Cortex Debug"
  - Open and edit .vscode/launch.json
    - change "executable" value into: "./build/STM32G0B1KE\_generated.elf" (example)
  - add lines:
    - "device": "STM32G0B1KE", or "STM32L432KC" or ...
    - "svdFile": "./STM32G0B1KE.svd", or "./STM32L4x2.svd" or ...
    - "runToMain": true
  - Set the commas right.
- Latest SVD Files can be found here: [https://www.st.com/content/st\\_com/en/search.html#q=svd-t=resources-page=1](https://www.st.com/content/st_com/en/search.html#q=svd-t=resources-page=1)
- Download file [./STM32G0B1.svd](#) from [https://www.st.com/resource/en/svd/stm32G0\\_svd.zip](https://www.st.com/resource/en/svd/stm32G0_svd.zip) (example)
  - Alternatively copy it from  
 "C:\ST\STM32CubeIDE\_1.13.1\STM32CubeIDE\plugins\com.st.stm32cube.ide.mcu.productdb.debug\_2.1.0.202306151215\resources\cmsis\STMicroelectronics\CMSIS\_SVD\STM32G0B1.svd" if you have the STM32CubeIDE installed.
  - Download file [./STM32L4x2.svd](#) from [https://www.st.com/resource/en/svd/stm32l4\\_svd.zip](https://www.st.com/resource/en/svd/stm32l4_svd.zip) (example)
- Installing the **Cortex Debug** extension allow you to debug the target code.

### 35.6. Makefile with Clang too

- After STM32 CubeMX code generation the Makefile was edited and spitted.
- STM32 CubeMX code generation accepts the edited Makefile, so re-generation is no issue.
  - It modifies the settings according to the changes.

### 35.7. Download Locations

#### 35.7.1. Clang

<https://releases.llvm.org/download.html> -> <https://github.com/llvm/llvm-project/releases/tag/llvmorg-16.0.0> (example)

#### 35.7.2. GCC

<https://developer.arm.com/Tools-and-Software/GNU-Toolchain> -> <https://developer.arm.com/downloads/-/arm-gnu-toolchain-downloads> (example))

### 35.8. Install Locations

Do not use locations containing spaces, like [C:\Program Files](#). Take [C:\bin](#) for example. This avoids trouble caused by spaces inside path names.

### 35.9. Environment Variables

Extend the path variable:

- PATH += [C:\bin\ArmGNUToolchain\bin](#)
- PATH += [C:\Program Files\SEGGER\JLink](#). (may be C:\Program Files\SEGGER\JLink\_V812a or similar)

### 35.10. Build command

- Clang: `make` or to get it faster `make -j8`.
- GCC: `make` `GCC`.

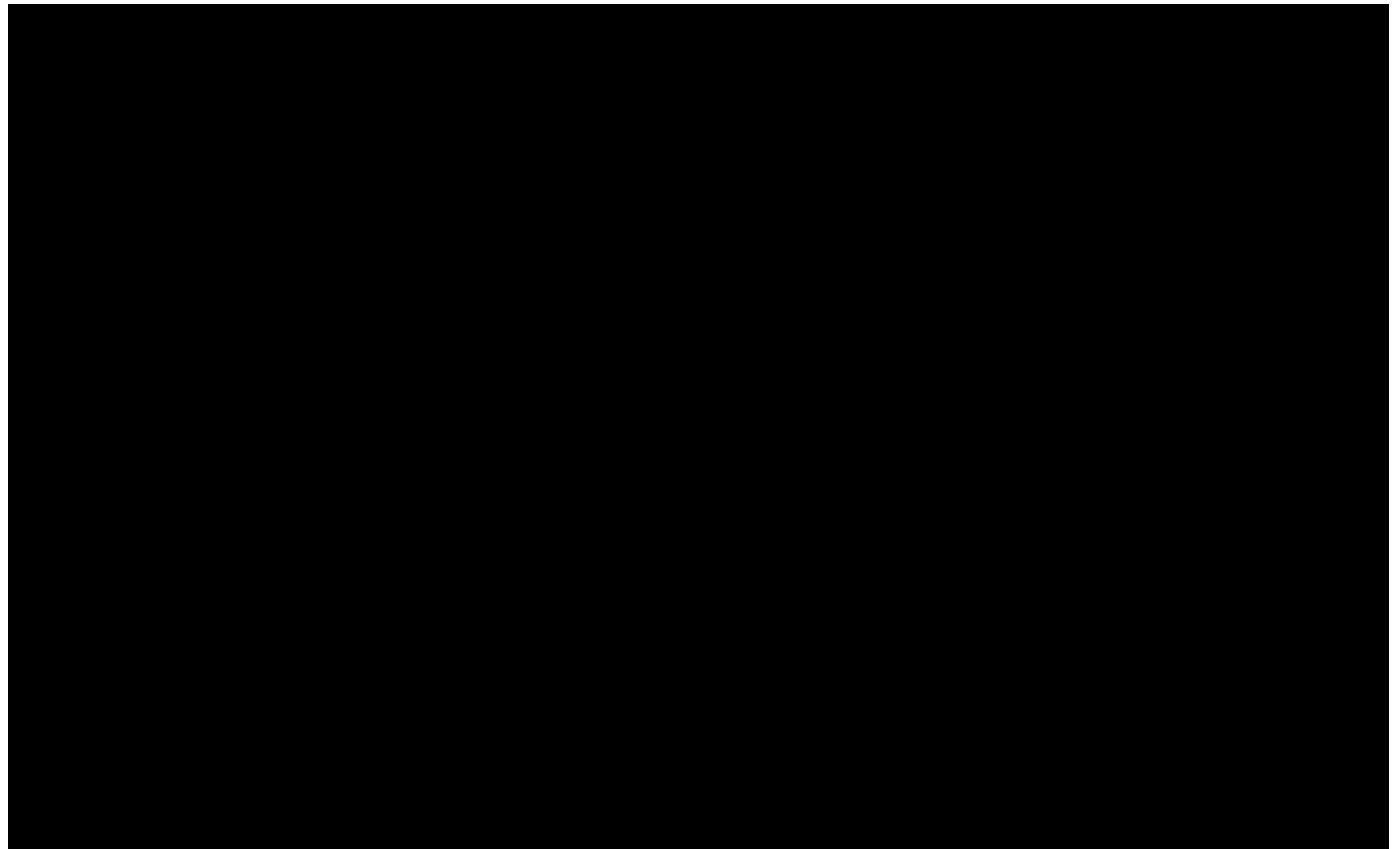
### 35.11. Run & Debug

- In terminal after `make` click Run&Debug & click green triangle.

### 35.12. Logging

- In terminal type `make log`. This executes the command in project folder:

```
trice l -p JLINK --args="--Device STM32G0B1RE --if SWD --Speed 4000 --RTTChannel 0" --pf none --ts ms --d16 (example)
```



### 35.13. Setting up a new project

- Copy this project folder under a new name like `myAwesomeNewProject` or name it as you like.
- Make a temporary folder `myTemp` and generate with STM CubeMX the base project.
- Copy the \*.ioc file from `myTemp` to `myAwesomeNewProject` and name it to the project name.
- Compare `myTemp\Makefile` with `myAwesomeNewProject\Makefile` and overwrite/extend in `myAwesomeNewProject\Makefile` the relevant settings, mainly the filenames, include path settings and DEFINES.
- Replace all generated files in `myAwesomeNewProject` with the ones in `myTemp`
- Replace the \*.svd file if the MCU is different. You can find it in the internet.
- Run `make -j8` inside `myAwesomeNewProject` to check if all is ok.
- Open the copied \*ioc file inside `myAwesomeNewProject` and re-generate and re-build to check.
- Compare the relevant files like `main.c` with the starting project and edit accordingly.
- Adapt `.vscode/launch.json` to the used MCU.
- Than the awesome new project should be ready to go for development.

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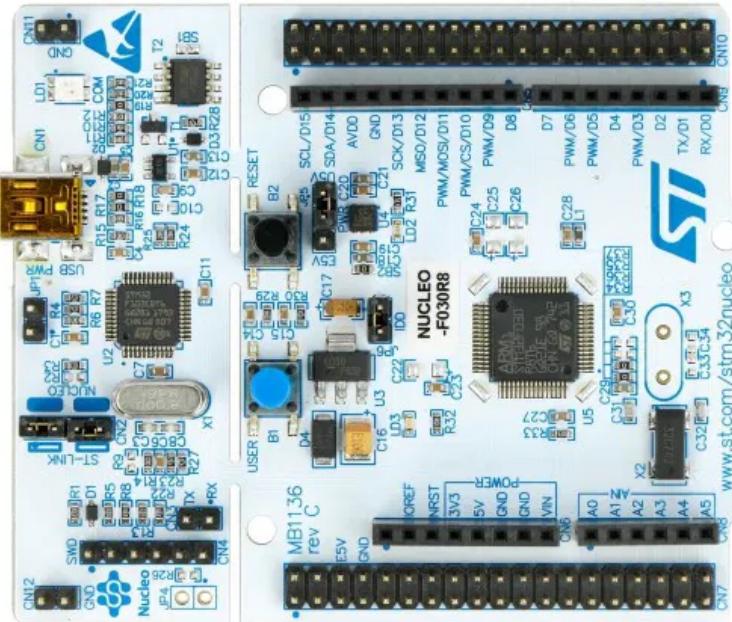
## 36. Example Projects without and with Trice Instrumentation

| Project Name | Description |
|--------------|-------------|
|              |             |

| Project Name             | Description                                                                                                                                                                                                                                                             |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| F030_bare                | This is a minimal STM32CubeMX generated Makefile project adapted to Clang and GCC. It serves as a reference for diff to <a href="#">F030_inst</a> so see quickly the needed instrumentation steps you need for your own project.                                        |
| F030_inst                | This is a minimal STM32CubeMX generated Makefile project adapted to Clang and GCC and afterward instrumented with the Trice library. Compare it with <a href="#">F030_bare</a> to see quickly how to instrument your project.                                           |
| G0B1_bare                | This is a minimal FreeRTOS STM32CubeMX generated Makefile project adapted to Clang and GCC.                                                                                                                                                                             |
| G0B1_inst                | This is a minimal FreeRTOS STM32CubeMX generated Makefile project adapted to Clang and GCC and afterward instrumented with the Trice library.                                                                                                                           |
| L432_bare                | This is a minimal FreeRTOS STM32CubeMX generated Makefile project extended to compile also with Clang trying to perform minimal changes. It produces some warnings, because it is not finetuned. The <a href="#">L432_inst</a> project is then a next step performable. |
| L432_inst                | This is a minimal FreeRTOS STM32CubeMX generated Makefile project adapted to Clang and GCC and afterward instrumented with the Trice library.                                                                                                                           |
| OpenCM3_STM32F411_Nucleo | See the <a href="#">Readme.md</a> in this folder.                                                                                                                                                                                                                       |

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### 36.1. Nucleo-F030R8 Examples



#### 36.1.1. F030\_bare

Folder: [../examples/F030\\_bare/](#)

This is a STMCubeMX generated project without Trice instrumentation for easy compare with [F030\\_inst](#) to figure out the needed changes to set up trice.

Steps performed as potential guide:

- Install STM32CubeMX to C:\SMT32SubeMX.

- Select NUCLEO-F030R8 board.
- Initialize with default values.
- Optionally set system clock to 32MHz for faster target timestamps.
- Optionally set UART baud rate to 115200.
- Mandatory set UART data bits including parity to **9**.
- Enable USART2 global interrupt.
- In Project Manager *Project*:
  - Set toolchain folder location to **E:\repos\trice\examples\F030\_bare\**.
  - Set project name to **F030\_bare**.
  - Set toolchain / IDE to **Makefile**.
- In Project Manager *Code Generator*:
  - Select "Copy only the necessary library files".
- In Project Manager *Advanced Settings*:
  - In Driver Selector change all to *LL*.
- Generate Code
- Start vsCode and open folder F030\_bare with it.
- Start a terminal and type **make**. The output should be similar to:

```

PS E:\repos\trice\examples\F030_bare> make -j8
mkdir build
arm-none-eabi-gcc -c -mcpu=cortex-m0 -mthumb -DUSE_FULL_LL_DRIVER -DHSE_VALUE=8000000 -
DHSE_STARTUP_TIMEOUT=100 -DLSE_STARTUP_TIMEOUT=5000 -DLSE_VALUE=32768 -DHSI_VALUE=8000000 -
DLISI_VALUE=40000 -DVDD_VALUE=3300 -DPREFETCH_ENABLE=1 -DINSTRUCTION_CACHE_ENABLE=0 -
DDATA_CACHE_ENABLE=0 -DSTM32F030x8 -ICore/Inc -IDrivers/STM32F0xx_HAL_Driver/Inc -
IDrivers/CMSIS/Device/ST/STM32F0xx/Include -IDrivers/CMSIS/Include -Og -Wall -fdata-sections -
ffunction-sections -g -gdwarf-2 -MMD -MP -MF"build/main.d" -Wa,-a,-ad,-alms=build/main.lst
Core/Src/main.c -o build/main.o

...
arm-none-eabi-gcc -x assembler-with-cpp -c -mcpu=cortex-m0 -mthumb -DUSE_FULL_LL_DRIVER -
DHSE_VALUE=8000000 -DHSE_STARTUP_TIMEOUT=100 -DLSE_STARTUP_TIMEOUT=5000 -DLSE_VALUE=32768 -
DHSI_VALUE=8000000 -DLISI_VALUE=40000 -DVDD_VALUE=3300 -DPREFETCH_ENABLE=1 -DINSTRUCTION_CACHE_ENABLE=0 -
DDATA_CACHE_ENABLE=0 -DSTM32F030x8 -ICore/Inc -IDrivers/STM32F0xx_HAL_Driver/Inc -
IDrivers/CMSIS/Device/ST/STM32F0xx/Include -IDrivers/CMSIS/Include -Og -Wall -fdata-sections -
ffunction-sections -g -gdwarf-2 -MMD -MP -MF"build/startup_stm32f030x8.d" startup_stm32f030x8.s -o
build/startup_stm32f030x8.o
arm-none-eabi-gcc build/main.o build/stm32f0xx_it.o build/stm32f0xx_ll_gpio.o build/stm32f0xx_ll_pwr.o
build/stm32f0xx_ll_exti.o build/stm32f0xx_ll_usart.o build/stm32f0xx_ll_rcc.o build/stm32f0xx_ll_dma.o
build/stm32f0xx_ll_utils.o build/system_stm32f0xx.o build/sysmem.o build/syscalls.o
build/startup_stm32f030x8.o -mcpu=cortex-m0 -mthumb -specs=nano.specs -TSTM32F030R8Tx_FLASH.ld -lc
-lm -lnosys -Wl,--Map=build/F030_bare.map,--cref -Wl,--gc-sections -o build/F030_bare.elf
C:/bin/ArmGNUToolchain/bin/../lib/gcc/arm-none-eabi/13.2.1/.../..../arm-none-eabi/bin/ld.exe:
warning: build/F030_bare.elf has a LOAD segment with RWX permissions
arm-none-eabi-size build/F030_bare.elf
 text data bss dec hex filename
 2428 12 1564 4004 fa4 build/F030_bare.elf
arm-none-eabi-objcopy -O ihex build/F030_bare.elf build/F030_bare.hex
arm-none-eabi-objcopy -O binary -S build/F030_bare.elf build/F030_bare.bin
PS E:\repos\trice\examples\F030_bare>

```

- Install vsCode Cortex-Debug extension.
- Create a `launch.json` file inside the `.vscode` subfolder and edit it to get

```
{
 // Use IntelliSense to learn about possible attributes.
 // Hover to view descriptions of existing attributes.
 // For more information, visit: https://go.microsoft.com/fwlink/?linkid=830387
 "version": "0.2.0",
 "configurations": [
 {
 "name": "Cortex Debug",
 "cwd": "${workspaceFolder}",
 "executable": "./build/F030_bare.elf",
 "request": "launch",

```

```

 "type": "cortex-debug",
 "runToEntryPoint": "main",
 "servertype": "jlink",
 "device": "STM32F030R8",
 "svdFile": "./STM32F030R8.svd",
 "runToMain": true

 }
]
}

```

- Download [STM32G030.svd](#) or get it from the STMCubeIDE installation folder if you want to install this Eclipse IDE as well, but IMHO you do not need it.
- You may need to extract and install the [STM32 USB drivers](#). You can find them also in [./third\\_party/st.com/en.stsw-link009\\_v2.0.2.zip](#).
- It is assumed, that you converted the OB ST-Link to an OB J-Link already. See [Convert Evaluation Board onboard ST-Link to J-Link](#) for details.
- Press the Debug-Button or "CTRL+SHIFT+D" and start debugging.

**Hint**

- During the code generation, the CubeMX tool did not copy `syscalls.c` and `sysmem.c` but added them to the Makefile. This seems to be a STM32CubeMX "feature".
  - You do not need these files for the example project, but you can add them manually to avoid some warnings or extend the code with:

```

__weak int _close(void) { return -1; }
__weak int _lseek(void) { return -1; }
__weak int _read (void) { return -1; }
__weak int _write(void) { return -1; }

```

**36.1.2. F030\_inst**

Folder: [../examples/F030\\_inst/](#)

This is a working example with deferred encrypted out over UART. By uncommenting 2 lines in `triceConfig.h`, you get also parallel direct out over RTT. For setup see [Trice over RTT](#) and adapt steps from [F030\\_bare](#).

**Intrumenting:**

- Extend the Makefile with the information you get from comparing the *Makefile* here and in [../F030R8\\_gen/](#).
- Add `build.sh` and `clean.sh`.
- Copy file `SEGGER_RTT_Conf.h` from `trice/third_party/segger.com/SEGGER_RTT_V760g.zip` to [./Core/Inc/](#). You could also look for a newer version.
- Copy and adapt a file `triceConfig.h` to [./Core/Inc/](#). You can choose from an other example project or one of the test folders.
- Create 2 empty files: `touch til.json li.json` inside `./`
- Run `build.sh`. This should build all.
- Add `#include "trice.h"` to `main.c` and to `stm32f0xx_it.c` and edit these files according to diff.
- Add to `int main( void )` some `Trice( "..." );` messages.
- Run `trice s` to determine the relevant comport.
- You can have this output:

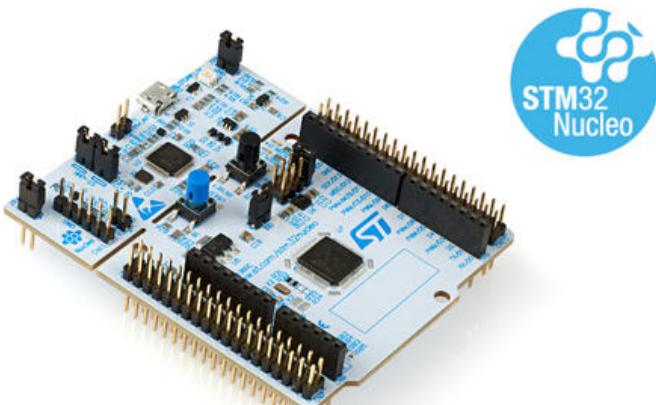
```
MINGW64:/c/Users/ms/repos/trice/examples/G0B1_inst
$ make log
trice 1 -p JLINK -args="-Device STM32G0B1RE -if SWD -Speed 4000 -RTTChannel 0" -pf none -ts ms -d16
Jul 22 11:24:30.538226 JLINK: main.c 79
Jul 22 11:24:30.538226 JLINK: * * * * * * * * * * * * * * * *
Jul 22 11:24:30.538226 JLINK: * * * * * * * * * * * * * * * *
Jul 22 11:24:30.538226 JLINK: * * * * * * * * * * * * * * * *
Jul 22 11:24:30.538226 JLINK: * * * * * * * * * * * * * * * *
Jul 22 11:24:30.538226 JLINK: * * * * * * * * * * * * * * * *
Jul 22 11:24:30.538226 JLINK: * * * * * * * * * * * * * * * *
Jul 22 11:24:30.538226 JLINK: main.c 79 Hello! ⚡ 2.71828182845904523536 (the full number as string)
Jul 22 11:24:30.538226 JLINK: main.c 95 0:00:00,002 Hello! ⚡
Jul 22 11:24:30.538226 JLINK: main.c 96 0:00:00,002 Hello! ⚡
Jul 22 11:24:30.538226 JLINK: main.c 97 0,066 Hello! ⚡
Jul 22 11:24:30.538226 JLINK: main.c 98 0,083 Hello! ⚡
Jul 22 11:24:30.538226 JLINK: main.c 99 Hello! ⚡
Jul 22 11:24:30.538226 JLINK: main.c 100 Hello! ⚡
Jul 22 11:24:30.538226 JLINK: main.c 101 0:00:00,002 Hello! ⚡ 1
Jul 22 11:24:30.538226 JLINK: main.c 102 0,154 Hello! ⚡ 1 2
Jul 22 11:24:30.538226 JLINK: main.c 103 0,175 Hello! ⚡ 1 2 3
Jul 22 11:24:30.538226 JLINK: main.c 104 Hello! ⚡ 2,718282 (default rounded float)
Jul 22 11:24:30.538226 JLINK: main.c 105 Hello! ⚡ 2,71828174591064453125 (float with more ciphers but not increased precision)
Jul 22 11:24:30.538226 JLINK: main.c 106 Hello! ⚡ 2,71828182845904509080 (double with more but limited precision but it is limited)
Jul 22 11:24:30.540386 JLINK: main.c 109 0:00:00,002 i=0
Jul 22 11:24:30.540386 JLINK: main.c 110 0,272 i=0
Jul 22 11:24:30.540386 JLINK: main.c 111 0,000,000 i=1

MINGW64:/c/Users/ms/repos/trice/examples/G0B1_inst
$ trice log -p com6
Jul 22 11:24:30.187019 com6: main.c 79
Jul 22 11:24:30.187019 com6: * * * * * * * * * * * * * * * *
Jul 22 11:24:30.187019 com6: * * * * * * * * * * * * * * * *
Jul 22 11:24:30.187019 com6: * * * * * * * * * * * * * * * *
Jul 22 11:24:30.187019 com6: * * * * * * * * * * * * * * * *
Jul 22 11:24:30.187019 com6: * * * * * * * * * * * * * * * *
Jul 22 11:24:30.187019 com6: * * * * * * * * * * * * * * * *
Jul 22 11:24:30.188078 com6: main.c 79 Hello! ⚡ 2.71828182845904523536 (the full number as string)
Jul 22 11:24:30.188601 com6: main.c 95 0,000,002 Hello! ⚡
Jul 22 11:24:30.190202 com6: main.c 96 0,000,002 Hello! ⚡
Jul 22 11:24:30.190742 com6: main.c 97 0,066 Hello! ⚡
Jul 22 11:24:30.192333 com6: main.c 98 0,083 Hello! ⚡
Jul 22 11:24:30.192855 com6: main.c 99 Hello! ⚡
Jul 22 11:24:30.194024 com6: main.c 100 Hello! ⚡
Jul 22 11:24:30.195091 com6: main.c 101 0,000,002 Hello! ⚡ 1
Jul 22 11:24:30.197766 com6: main.c 102 0,154 Hello! ⚡ 1 2
Jul 22 11:24:30.198524 com6: main.c 103 0,175 Hello! ⚡ 1 2 3
Jul 22 11:24:30.198524 com6: main.c 104 Hello! ⚡ 2,718282 (default rounded float)
Jul 22 11:24:30.199031 com6: main.c 105 Hello! ⚡ 2,71828174591064453125 (float with more ciphers but not increased precision)
Jul 22 11:24:30.200108 com6: main.c 106 Hello! ⚡ 2,71828182845904509080 (double with more but limited precision but it is limited)
Jul 22 11:24:30.201731 com6: main.c 109 0,000,002 i=0
Jul 22 11:24:30.202805 com6: main.c 110 0,272 i=0
Jul 22 11:24:30.204416 com6: main.c 109 0,000,000 i=1
```

- The Trices with 16-bit timestamps are about 150 clocks away from each other. @32MHz this is a time of less 5  $\mu$ s.

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## 36.2. Nucleo-G0B1 Examples



### 36.2.1. G0B1\_bare

Folder: [..../examples/G0B1\\_bare/](#)

#### G0B1\_bare Description

- This is a working example with CLang and also GCC.
- This is a STMCubeMX generated project. It was then manually adapted to Clang.
- It is without TRICE instrumentation for easy compare with [..../G0B1\\_inst](#) to figure out the needed changes to set up trice.

#### Setting Up G0B1\_bare

- See and adapt steps from [F030\\_bare](#).

- Then add/modify the files to reach this folder layout.

### 36.2.2. G0B1\_inst

Folder: [..../examples/G0B1\\_inst/](#)

This is an example with direct out without framing over RTT and deferred out in TCOBS framing over UART.

#### Setting Up

- See and adapt steps from [G0B1\\_bare](#).

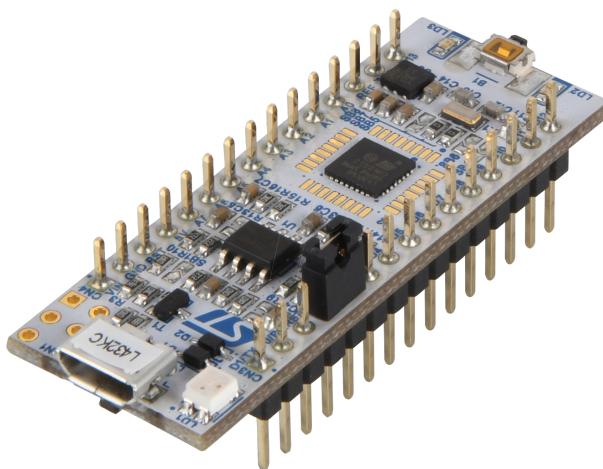
#### Instrumenting

- The steps are similar to the steps in [F030\\_bare](#).
- See comments in [triceConfig.h](#) and commandlines in screenshot.

```
ms@LenovoP51Win11 MINGW64 /e/repos/trice/examples/F030R8_inst (master)
$ trice l -p com5 -pf cobs -pw MySecret -showID "d:%04x" -ts16 "time: %%6d"
Jul 22 23:06:44.644126 com5: main.c 71 1682
Jul 22 23:06:44.644725 com5:
Jul 22 23:06:44.646768 com5: main.c 109 # 28445 1206 Hello! 🤖
Jul 22 23:06:44.647324 com5: main.c 107 # 28294 0cf8 Hello! 🤖
Jul 22 23:06:44.647324 com5: main.c 106 # 28142 1205 Hello! 🤖
Jul 22 23:06:44.647992 com5: main.c 104 0,000,000 0b76 Hello! 🤖
Jul 22 23:06:44.648559 com5: main.c 105 0,000,000 0eff Hello! 🤖
Jul 22 23:06:44.649938 com5: main.c 106 # 27693 1205 Hello! 🤖
Jul 22 23:06:44.650448 com5: main.c 107 # 27544 0cf8 Hello! 🤖
Jul 22 23:06:44.651792 com5: main.c 108 # 27393 07b3 Hello! 🤖
Jul 22 23:06:44.652364 com5: main.c 109 # 27244 1206 Hello! 🤖
Jul 22 23:06:44.653849 com5: main.c 110 0706 Hello! 🤖
Jul 22 23:06:44.653849 com5: main.c 111 0c51 Hello! 🤖
Jul 22 23:06:44.732464 com5: triceCheck.c 1500 Becc 01
Jul 22 23:06:44.833793 com5: triceCheck.c 1500 Becc 012
Jul 22 23:06:44.933973 com5: triceCheck.c 1500 Becc 0123
```

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### 36.3. Nucleo-L432KC Examples



#### 36.3.1. L432\_bare

Folder: [..../examples/L432\\_bare/](#)

- [NUCLEO L432 User Manual](#) (example)
- This example is without Trice instrumentation and serves for comparing with [L432\\_inst](#) to see the needed instrumentation steps quickly.
- This is a STMCubeMX generated project.
- See and adapt steps from [F030\\_bare](#) example.
- It was then manually adapted additionally to Clang.

- It was additionally configured for FreeRTOS.

### 36.3.2. L432\_inst

Folder: [..](#)/examples/L432\_inst/

- This is the with Trice instrumented example project [L432\\_bare](#).
  - It is for easy compare to figure out the needed setup changes.
  - See and adapt steps in [F030\\_bare](#).
  - Then add/modify the files to reach this folder layout.

## Build:

Run `./build.sh` for configuration 0 or `./build.sh CONFIGURATION=34` for example.

## Deferred Mode for max Speed

The stamps are MCU clocks here, so  Speedy Gonzales lasts 9 processor clocks here.

```

ms@DESKTOP-7P0EGPB MINGW64 ~/repos/trice_wt-devel/examples/L432_inst (devel)
$ trice l -p com8 -hs off -prefix off
triceExamples.c 10 0_272 Hello! 🙌😊

***** NUCLEO-L432KC *****
balloons

triceConfig.h 369 CONFIGURATION == 34 - UART, no cycle counter, no critical
sections.
triceExamples.c 45 TRICE_DIRECT_OUTPUT == 0, TRICE_DEFERRED_OUTPUT == 1
triceExamples.c 51 TRICE_DOUBLE_BUFFER, TRICE_MULTI_PACK_MODE
triceExamples.c 60 _CYCLE == 0, _PROTECT == 0, _DIAG == 0, XTEA == 0
triceExamples.c 61 _SINGLE_MAX_SIZE=512, _BUFFER_SIZE=580,
_DEFERRED_BUFFER_SIZE=4096
triceExamples.c 15 0_000_731 🎉 Speedy Gonzales
triceExamples.c 16 0_000_745 🎉 Speedy Gonzales
triceExamples.c 17 0_000_754 🎉 Speedy Gonzales
triceExamples.c 18 0_000_763 🎉 Speedy Gonzales
triceExamples.c 19 0_000_772 🎉 Speedy Gonzales
triceExamples.c 20 0_000_781 🎉 Speedy Gonzales
triceExamples.c 21 0_000_790 🎉 Speedy Gonzales
triceExamples.c 22 0_000_799 🎉 Speedy Gonzales
triceExamples.c 24 0_981 2.71828182845904523536 <- float number as string
triceExamples.c 25 1_230 2.71828182845904509080 (double with more ciphers than
precision)
triceExamples.c 26 1_268 2.71828174591064453125 (float with more ciphers than
precision)
triceExamples.c 27 1_296 2.718282 (default rounded float)
triceExamples.c 28 1_310 A Buffer:
triceExamples.c 29 1_348 32 2e 37 31 38 32 38 31 38 32 38 34 35 39 30 34 35 32 33 35
33 36
triceExamples.c 30 1_603 31372e32 31383238 34383238 34303935 35333235
triceExamples.c 31 1_799 ARemoteFunctionName(2e32)(3137)(3238)(3138)(3238)(3438)(3935)
(3430)(3235)(3533)(3633)
triceExamples.c 32 10 times a 16 byte long Trice messages, which not all will be
written because of the TRICE_PROTECT:
triceExamples.c 34 2_072 i=44444400 aaaaaa00
triceExamples.c 34 2_119 i=44444401 aaaaaa01
triceExamples.c 34 2_166 i=44444402 aaaaaa02

```

## "Hardware" Changes

- The used evaluation board is delivered with an on-board ST-Link software for debugging.
  - This was changed to an on-board J-Link software for better debugging and RTT support.
  - See [Trice over RTT](#) about that.

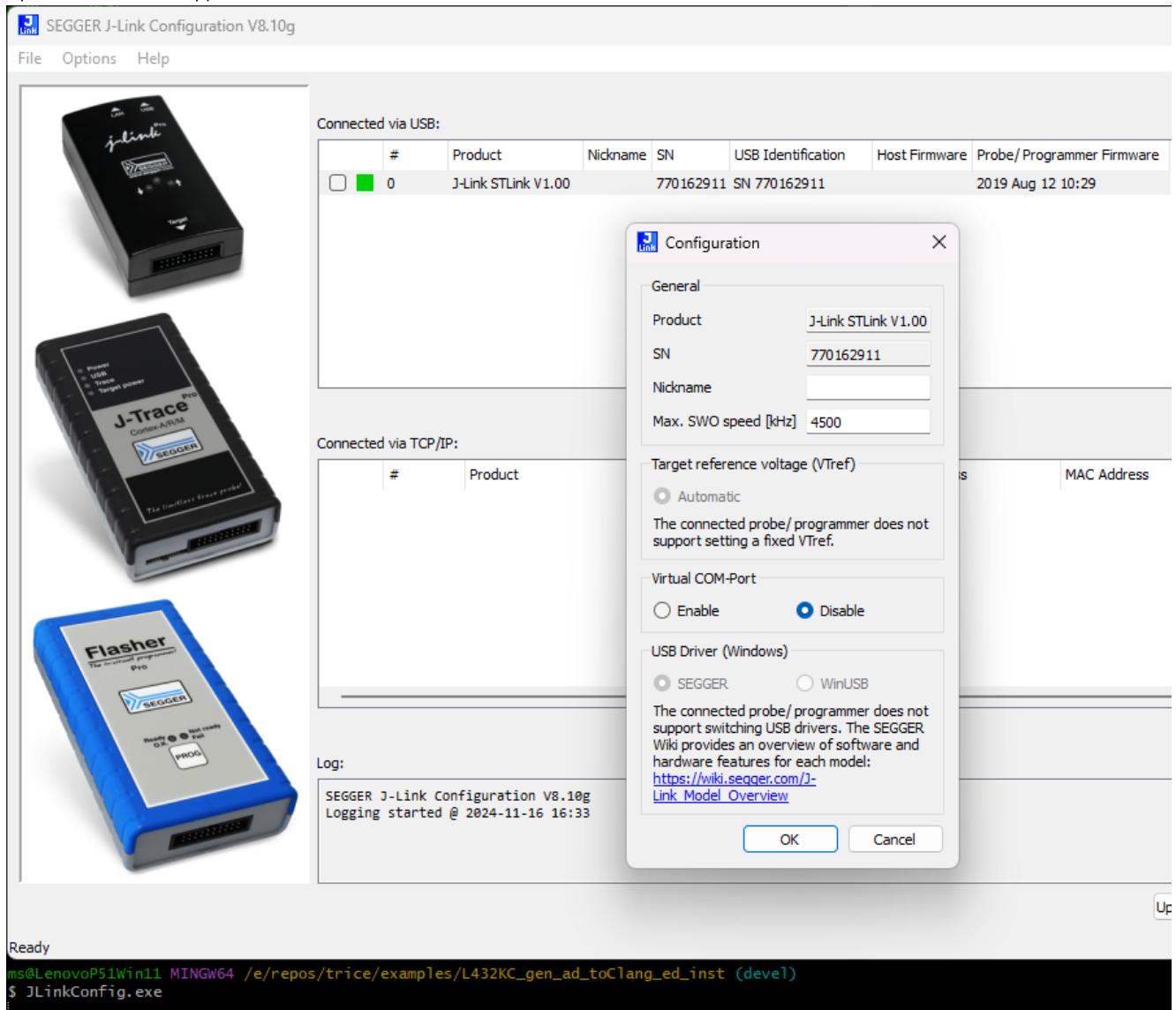
### Using RTT with on-board J-Link and JLinkRTTLogger

- You need to install the "J-Link Software and Documentation pack" for your OS.
- [./Core/Inc/triceConfig.h](#) contains example Trice log commands.

### Using RTT with on-board J-Link and OpenOCD

With Windows not possible

- OpenOCD does not support the installed JLink driver.



- Changing to the WinUSB build device driver is here not supported 😞

Darwin

- See [OpenOCD with Darwin](#) in [Trice over RTT](#)

### Using RTT with on-board ST-Link and OpenOCD

#### Terminal 1:

```
ms@LenovoP51Win11 MINGW64 /e/repos/trice/examples/L432_inst (devel)
$ openocd -f STLinkOpenOCD.cfg
Open On-Chip Debugger 0.12.0 (2024-09-16) [https://github.com/sysprogs/openocd]
Licensed under GNU GPL v2
libusb1 d52e355daa09f17ce64819122cb067b8a2ee0d4b
For bug reports, read
 http://openocd.org/doc/doxygen/bugs.html
```

```
Info : The selected transport took over low-level target control. The results might differ compared to plain JTAG/SWD
Info : clock speed 100 kHz
Info : STLINK V2J24M11 (API v2) VID:PID 0483:374B
Info : Target voltage: 72.811768
Info : [stm32l4x.cpu] Cortex-M4 r0p1 processor detected
Info : [stm32l4x.cpu] target has 6 breakpoints, 4 watchpoints
Info : [stm32l4x.cpu] Examination succeed
Info : [stm32l4x.cpu] starting gdb server on 3333
Info : Listening on port 3333 for gdb connections
Info : rtt: Searching for control block 'SEGGER RTT'
Info : rtt: Control block found at 0x2000145c
Info : Listening on port 9090 for rtt connections
Channels: up=1, down=3
Up-channels:
0: Terminal 1024 0
Down-channels:
0: Terminal 16 0
Info : Listening on port 6666 for tcl connections
Info : Listening on port 4444 for telnet connections
```

## Terminal2:

```
ms@LenovoP51Win11 MINGW64 /e/repos/trice/examples/L432_inst (devel)
$ trice l -p TCP4 -args localhost:9090 -pf none -d16
Nov 16 20:38:12.376056 TCP4: triceExamples.c 10 1_595 Hello! 🙌😊
Nov 16 20:38:12.376056 TCP4:
Nov 16 20:38:12.376056 TCP4: ✨✨✨✨✨✨✨✨✨✨✨✨✨
Nov 16 20:38:12.376056 TCP4: 🎈🎈🎈🎈 MUCLEO-L432KC 🎈🎈🎈🎈
Nov 16 20:38:12.376056 TCP4: 🍀🍀🍀🍀🍀🍀🍀🍀🍀🍀🍀🍀🍀🍀🍀
Nov 16 20:38:12.376056 TCP4:
Nov 16 20:38:12.376056 TCP4:
Nov 16 20:38:13.891033 TCP4: triceExamples.c 16 43_439 2.71828182845904523536 <- float
number as string
Nov 16 20:38:14.874024 TCP4: triceExamples.c 17 44_949 2.71828182845904509080 (double
with more ciphers than precision)
Nov 16 20:38:15.692614 TCP4: triceExamples.c 18 45_802 2.71828174591064453125 (float
with more ciphers than precision)
Nov 16 20:38:16.323665 TCP4: triceExamples.c 19 46_536 2.718282 (default rounded
float)
```

Using On-board ST-Link and VS-Code Cortex-Debug Extension

Fail

- [https://www.st.com/resource/en/user\\_manual/um2576-stm32cubeide-stlink-gdb-server-stmicroelectronics.pdf](https://www.st.com/resource/en/user_manual/um2576-stm32cubeide-stlink-gdb-server-stmicroelectronics.pdf)
  - Downloaded and installed
    - en.stm32cubeprg-win64-v2-17-0.zip
    - en.st-link-server-v2-1-1.zip
      - PATH variable extended with C:\Program Files (x86)\STMicroelectronics\stlink\_server
      - Copied
        - From: "C:\Program Files (x86)\STMicroelectronics\stlink\_server\stlinkserver.exe"
        - To: "C:\Program Files (x86)\STMicroelectronics\stlink\_server\ST-LINK\_gdbserver.exe"

ok

- Download st-util from [github.com](http://github.com)
  - Unpack to `C:\bin\stlink-1.8.0-win32` and add `C:\bin\stlink-1.8.0-win32\bin` to path
  - Copy `C:\bin\stlink-1.8.0-win32\Program Files (x86)\stlink` to `C:\Program Files (x86)\stlink`
  - Get `C:\bin\libusb-1.0.27`
  - Copy `C:\bin\libusb-1.0.27\MinGW64\ dll\libusb-1.0.dll` to `C:\bin\stlink-1.8.0-win32\bin\libusb-1.0.dll`

```
ms@LenovoP51Win11 MINGW64 /e/repos/trice/examples/L432_inst (devel)
$ st-util.exe
```

```
st-util 1.8.0
libusb: info [get_guid] no DeviceInterfaceGUID registered for 'USB\VID_056A&PID_5105\5&1140C04&0&10'
libusb: info [get_guid] no DeviceInterfaceGUID registered for
'USB\VID_056A&PID_5105&MI_01\6&13339912&0&0001'
libusb: info [get_guid] no DeviceInterfaceGUID registered for 'USB\VID_058F&PID_9540\5&1140C04&0&11'
libusb: info [get_guid] no DeviceInterfaceGUID registered for 'USB\VID_8087&PID_0A2B\5&1140C04&0&14'
libusb: info [get_guid] no DeviceInterfaceGUID registered for 'USB\ROOT_HUB30\4&20F1DF2E&0&0'
libusb: info [get_guid] no DeviceInterfaceGUID registered for 'USB\VID_0765&PID_5010\5&1140C04&0&13'
libusb: info [get_guid] no DeviceInterfaceGUID registered for
'USB\VID_0483&PID_374B&MI_01\6&224DEA1D&0&0001'
libusb: info [get_guid] no DeviceInterfaceGUID registered for
'USB\VID_5986&PID_111C&MI_00\6&104790C2&0&0000'
libusb: info [get_guid] no DeviceInterfaceGUID registered for 'USB\VID_046D&PID_C534\5&1140C04&0&6'
libusb: info [get_guid] no DeviceInterfaceGUID registered for
'USB\VID_0483&PID_374B&MI_02\6&224DEA1D&0&0002'
libusb: info [get_guid] no DeviceInterfaceGUID registered for
'USB\VID_0483&PID_374B\066CFF515570514867145144'
libusb: info [get_guid] no DeviceInterfaceGUID registered for 'USB\VID_138A&PID_0097\72FA8C531499'
libusb: info [get_guid] no DeviceInterfaceGUID registered for
'USB\VID_056A&PID_5105&MI_00\6&13339912&0&0000'
libusb: info [get_guid] no DeviceInterfaceGUID registered for
'USB\VID_046D&PID_C534&MI_01\6&C944391&0&0001'
libusb: info [get_guid] no DeviceInterfaceGUID registered for
'USB\VID_046D&PID_C534&MI_00\6&C944391&0&0000'
libusb: info [get_guid] no DeviceInterfaceGUID registered for 'USB\VID_5986&PID_111C\200901010001'
2024-11-17T22:20:05 INFO common.c: STM32L41x_L42x: 48 KiB SRAM, 256 KiB flash in at least 2 KiB pages.
2024-11-17T22:20:05 INFO gdb-server.c: Listening at *:4242...
Receive signal 0. Exiting...
```

(Last line after **CTRL-C**)

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## 37. Trice Generate

### 37.1. Colors

Support for finding a color style:

```
ms@DESKTOP-7POEGPB MINGW64 ~/repos/trice_wt-devel (devel)
$ trice generate -colors
 0: black:black:black:black
 1: black+b:black:black+b:black
 2: black+B:black:black+B:black
 3: black+u:black:underline:black
 4: black+i:black:black+i:black
 5: black+s:black:strike:black
 6: black+h:black:black+h:black
 red:black:red:black
 8: red+b:black:red+b:black
 9: red+B:black:red+B:black
10: red+u:black:red+u:black
11: red+i:black:red+i:black
12: red+s:black:red+s:black
13: red+h:black:red+h:black
14: green:black:green:black
15: green+b:black:green+b:black
```

See [Check Alternatives](#) chapter.

### 37.2. C-Code

If you intend to get the `trice log` functionality full or partially as a `tlog` C-Source and do not wish to parse the `til.json` file, you can run `trice generate -tilH --tilC` to create a C-file with header as starting point. That could be interesting for compiling the log functionality into a

small separate microcontroller board.

```
///! \file til.c
///! //
///! Trice generated code - do not edit!

#include "til.h"

///! triceFormatStringList contains all trice format strings together with id and parameter
///! information.
///!
///! The bitWidth value is not transmitted in the binary data stream and needed for its decoding.
///! The paramInt is de-facto not needed. It is derivable from the received data, see
///! docs/TriceUserManual.md/#binary-encoding.
///! It is recommended to check if both values are matching. A negative paramInt indicates, that its
///! value is unknown at compile time.
const triceFormatStringList_t triceFormatStringList[] = {
 /* Trice type (extended) */ // id, bitWidth, paramInt, format-string
 /* trice (trice32_9) */ { 14016, 32, 9, "rd:trice %d, %d, %d, %d, %d, %d, %d, %d\n" },
}, /* trice (trice0) */ { 14224, 32, 0, "\n" },
/* trice32 (trice32_1) */ { 14337, 32, 1, "msg:%u (%u)\n" },
/* TRICE8 (TRICE8_10) */ { 15063, 8, 10, "rd:TRICE8 %d, %d, %d, %d, %d, %d, %d, %d, %d\n" },
/* Trice8 (Trice8_9) */ { 15124, 8, 9, "rd:Trice8 %d, %d, %d, %d, %d, %d, %d, %d\n" },
}, /* TRICE8 (TRICE8_5) */ { 15058, 8, 5, "rd:TRICE8 %d, %d, %d, %d, %d\n" },
/* TRice (TRice0) */ { 14885, 32, 0, "TEST:yellow+h:black\n" },
/* Trice64 (Trice64_1) */ { 15560, 64, 1, "rd:Trice64 %d\n" },
/* trice (trice32_1) */ { 15860, 32, 1, "rd:TRICE float %9.f (%9.f)\n" },
...
/* TRICE64_0 (TRICE64_0) */ { 16157, 64, 0, "w: Hello! 🎉😊 \a\n" },
/* TRICE (TRICE0) */ { 14658, 32, 0, "interrupt:magenta+i:default+h\n" },
};

//! triceFormatStringListElements holds the compile time computed count of list elements.
const unsigned triceFormatStringListElements = sizeof(triceFormatStringList) /
sizeof(triceFormatStringList_t);
```

### 37.3. C#-Code

With `trice generate -tilCS` a starting point for a C-Sharp application is generated:

```
///! \file til.cs

// Trice generated code - do not edit!

// There is still a need to exchange the format specifier from C to C# !!!!!!!!!!!!!!!!!!!!!!!!
// See https://stackoverflow.com/questions/33432341/how-to-use-c-language-format-specifiers-in-c-sharp
// and https://www.codeproject.com/Articles/19274/A-printf-implementation-in-C for possible help.

namespace TriceIDLList;

public class TilItem
{
 public TilItem(int bitWidth, int paramInt, string strg)
 {
 BitWidth = bitWidth;
 ParamCount = paramInt;
 Strg = strg;
 }

 public int BitWidth { get; init; }
 public int ParamCount { get; init; }
 public string Strg { get; init; }
}
```

```
///! Til contains all trice format strings together with id and parameter information.
///
///! The bitWidth value is not transmitted in the binary data stream and needed for its decoding.
///! The paramInt is de-facto not needed. It is derivable from the received data, see
docs/TriceUserManual.md/#binary-encoding.
///! It is recommended to check if both values are matching. A negative paramInt indicates, that
its value is unknown at compile time.
public static class Til
{
 public static readonly Dictionary<int, TilItem> TilList= new Dictionary<int, TilItem>
 { /* triceType (extended) */ // id, TilItem(bitWidth, paramInt, Strg)
 /* TRICE_12 (TRICE32_12)*/ { 14991, new TilItem(32, 12, "rd:TRICE_12 %d, %d, %d, %d, %d,
%d, %d, %d, %d, %d\n") },
 /* TRICE (TRICE32_1)*/ { 15636, new TilItem(32, 1, "WR:write message, SysTick
is %6u\n") },
 /* TRICE_S (TRICE_S)*/ { 14178, new TilItem(32, -1, "msg:With TRICE_S:%s\n") },
...
 /* TRICE16 (TRICE16_2)*/ { 16056, new TilItem(16, 2, "rd:TRICE16 %p, %p\n") },
 };
}
```

### 37.4. Generating a RPC Function Pointer List

When several embedded devices are going to communicate, `trice generate -rpch -rpcc` could be helpful.

You will get 2 files similar to:

```
///! \file tilRpc.h
///! //
///! Trice generated code – do not edit!

#include <stdint.h>

typedef void (*triceRpcHandler_t)(void* buffer, int count);

typedef struct{
 int id;
 triceRpcHandler_t fn;
} triceRpc_t;

extern triceRpc_t triceRpc[];
extern int triceRpcCount;

/* TRICE16_F */ void FunctionNameXa(int16_t* p, int cnt);
/* TRICE32_F */ void FunctionNameYa(int32_t* p, int cnt);
/* TRICE8_F */ void TryoutBufferFunction(int8_t* p, int cnt);
/* TRice16F */ void FunctionNameXb(int16_t* p, int cnt);
/* trice32F */ void FunctionNameYd(int32_t* p, int cnt);
/* TRice8F */ void FunctionNameWb(int8_t* p, int cnt);
/* trice64F */ void FunctionNameZd(int64_t* p, int cnt);
/* Trice16F */ void ARemoteFunctionName(int16_t* p, int cnt);
/* Trice8F */ void FunctionNameWc(int8_t* p, int cnt);
/* Trice16F */ void FunctionNameXc(int16_t* p, int cnt);
/* TRICE8_F */ void TryoutStructFunction(int8_t* p, int cnt);
/* Trice64F */ void FunctionNameZc(int64_t* p, int cnt);
/* trice8F */ void FunctionNameWd(int8_t* p, int cnt);
/* TRice64F */ void FunctionNameZb(int64_t* p, int cnt);
/* TRICE64_F */ void FunctionNameZa(int64_t* p, int cnt);
/* trice16F */ void FunctionNameXd(int16_t* p, int cnt);
/* TRICE8_F */ void FunctionNameWa(int8_t* p, int cnt);
/* TRice32F */ void FunctionNameYb(int32_t* p, int cnt);
/* Trice32F */ void FunctionNameYc(int32_t* p, int cnt);

// End of file
```

```

///! \file tilRpc.c
///! //

///! Trice generated code – do not edit!

#include <stdio.h> // needed for __attribute__((weak))
#include "tilRpc.h"

///! triceRpc contains all rpc IDs together with their function pointer address.
const triceRpc_t triceRpc[] = {
 /* Trice type */ // id, function pointer
 /* TRice8F */ { 14227, FunctionNameWb },
 /* TRICE32_F */ { 14234, FunctionNameYa },
 /* TRICE8_F */ { 16179, TryoutBufferFunction },
 /* Trice16F */ { 14232, FunctionNameXc },
 /* Trice64F */ { 14240, FunctionNameZc },
 /* TRice64F */ { 14239, FunctionNameZb },
 /* TRICE16_F */ { 14230, FunctionNameXa },
 /* TRICE8_F */ { 16178, TryoutStructFunction },
 /* Trice8F */ { 14228, FunctionNameWc },
 /* trice16F */ { 14233, FunctionNameXd },
 /* trice64F */ { 14241, FunctionNameZd },
 /* trice32F */ { 14237, FunctionNameYd },
 /* TRICE8_F */ { 14226, FunctionNameWa },
 /* TRice16F */ { 14231, FunctionNameXb },
 /* TRice32F */ { 14235, FunctionNameYb },
 /* Trice16F */ { 16337, ARemoteFunctionName },
 /* trice8F */ { 14229, FunctionNameWd },
 /* Trice32F */ { 14236, FunctionNameYc },
 /* TRICE64_F */ { 14238, FunctionNameZa }
};

///! triceRpcListElements holds the compile time computed count of list elements.
const unsigned triceRpcElements = sizeof(triceRpc) / sizeof(triceRpc_t);

void TryoutBufferFunction(int8_t* p, int cnt) __attribute__((weak)) {}
void FunctionNameXc(int16_t* p, int cnt) __attribute__((weak)) {}
void FunctionNameZc(int64_t* p, int cnt) __attribute__((weak)) {}
void FunctionNameZb(int64_t* p, int cnt) __attribute__((weak)) {}
void FunctionNameXa(int16_t* p, int cnt) __attribute__((weak)) {}
void TryoutStructFunction(int8_t* p, int cnt) __attribute__((weak)) {}
void FunctionNameWc(int8_t* p, int cnt) __attribute__((weak)) {}
void FunctionNameXd(int16_t* p, int cnt) __attribute__((weak)) {}
void FunctionNameZd(int64_t* p, int cnt) __attribute__((weak)) {}
void FunctionNameYd(int32_t* p, int cnt) __attribute__((weak)) {}
void FunctionNameWa(int8_t* p, int cnt) __attribute__((weak)) {}
void FunctionNameXb(int16_t* p, int cnt) __attribute__((weak)) {}
void FunctionNameYb(int32_t* p, int cnt) __attribute__((weak)) {}
void ARemoteFunctionName(int16_t* p, int cnt) __attribute__((weak)) {}
void FunctionNameWd(int8_t* p, int cnt) __attribute__((weak)) {}
void FunctionNameYc(int32_t* p, int cnt) __attribute__((weak)) {}
void FunctionNameZa(int64_t* p, int cnt) __attribute__((weak)) {}
void FunctionNameWb(int8_t* p, int cnt) __attribute__((weak)) {}
void FunctionNameYa(int32_t* p, int cnt) __attribute__((weak)) {}

// End of file

```

Assume a project with several devices. You can add these 2 files to all targets and if a special target should execute any functions, simply implement them. These functions on their own can execute other Trice statements to transmit results. If a client executes a RPC function this way, the request is transmitted with the Trice speed. Several target devices (servers) can receive and respond and the client can wait for the first or some of them. That server receiving and client waiting functionality is not part of the Trice library.

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## 38. Testing the Trice Library C-Code for the Target

### 38.1. General info

This folder is per default named to `_test` to avoid vsCode slow down. Also, when running `go test ./...`, the tests in the `_test` folder are excluded, because they take a long time. Run `./testAll.sh` to include them.

The main aim of these tests is to automatic compile and run the target code in different compiler switch variants avoiding manual testing this way.

- ALSO: In `./examples` you can translate all examples with `./buildAllTargets.sh`.
- ALSO: In `./examples/L432_inst` the script `all_configs_build.sh` translates many different configurations.

For the user it could be helpful to start with a `triceConfig.h` file from here and to adapt the Trice tool command line from the matching `cgo_test.go` if no close match in the `examples` folder was found.

### 38.2. How to run the tests

- In `_trice` folder first execute `go clean -cache`. Cleaning the Go cache is recommended, because the CGO tests keep pre-compiled files and when editing C-files, this can led to confusing results.
- Execute `./renewIDs_in_examples_and_test_folder.sh` after you edited files in the `./examples` or `_test` folder.
- To run the tests manually `cd` into `_test` and execute `trice insert -i ./testdata/til.json -li ./testdata/li.json` and then `go test ./...` fom there.
- It is convenient to run `testAll.sh` from the Trice root folder to perform this.

### 38.3. Tests Details

All folders despite `testdata` are test folders and the name `tf` is used as a place holder for them in this document.

To exclude a specific folder temporary, simply rename it to start with an underscore `_tf`.

The `tf` are serving for target code testing in different configuration variants on the host machine. The file `./testdata/triceCheck.c` is the master file for most tests and serves also as example usage.

`./testdata/cgoPackage.go` is the common master for the `generated_cgoPackage.go` files and contains the common test code.

The folders `tf` are Go packages just for tests. They all have the same package name `cgot` and are not included into the trice tool. The different `cgot` packages are independent and could have any names. They do not see each other and are used for target code testing independently. When the tests are executed for each package, a separate test binary is build and these run parallel.

The `tf/triceConfig.h` files differ and correspondent to the `tf/cgo_test.go` files in the same folder. On test execution, the `./testdata/*.c` files are compiled into the trice test executable together with the trice sources `../src` using the `tf/triceConfig.h` file.

The individual tests collect the expected results (`//exp: result`) together with the line numbers into a slice to execute the test loop on it. The `triceLogTest` function gets the `triceLog` function as parameter.

`triceLogTest` iterates over the results slice and calls for each line the C-function `triceCheck`. Then the line specific binary data buffer is passed to the `triceLog` parameter function which "logs" the passed buffer into an actual result string which in turn is compared with the expected result.

The whole process is relatively slow because of the often passed Go - C barrier, but allows automated tests in different configuration variants in one shot.

The `testdata\cgoPackage.go` file contains a variable `testLines = n`, which limits the amount of performed trices for each test case to `n`. Changing this value will heavily influence the test duration. The value `-1` is reserved for testing all test lines.

### 38.4. How to add new test cases

- Choose a test folder similar to the intended test and copy it under a new descriptive name like `newTest`.
- Extend file `./renewIDs_in_examples_and_test_folder.sh` accordingly.
- Edit files `newTest/triceConfig.h` and `newTest/cgo_test.go` in a matching way.
- Run command `go test test/newTest/...`

### 38.5. Test Internals

The `./trice/_test/testdata/*.c` and `./trice/src/*.c` are compiled together with the actual cgot package into one singe Trice test binary, resulting in as many test binaries as there are test folders. Calling its `TestFunction(s)` causes the activation of the Trice statement(s) inside `triceCheck.c`. The ususally into an embedded device compiled Trice code generates a few bytes according to the configuration into a buffer. These bytes are transmitted usually in real life over a (serial) port or RTT. In the tests here, this buffer is then read out by the Trice tool handler function according to the used CLI switches and processed to a log string using the `til.json` file. This string is then compared to the expected string for the activated line.

Each `tf` is a **Go** package, which is not part of any **Go** application. They all named `cgot` and are only used independently for testing different configurations. The `tf/generated_cgoPackage.go` file is identical in all `tf`. Its master is `testdata/cgoPackage.go`. After editing the master, running the command `./renewIDs_in_examples_and_test_folder.sh` copies the master to all `tf` and renames it to `generated_cgoPackage.go`.

The test specific target code configuration is inside `tf/trice.Config.h` and the appropriate Trice tool CLI switches are in `tf/cgo_test.go`.

When running `go test ./tf`, a Trice tool test executable is build, using the Trice tool packages and the `tf` package `cgot`, and the function `TestLogs` is executed. Its internal closure `triceLog` contains the Trice tool CLI switches and is passed to the `ccgot` package function `triceLogTest` together with the number of testLines and the trice mode (`directTransfer` or `deferrerdTransfer`).

During the test, the file `triceCheck.c` is scanned for lines like

```
break; case __LINE__: TRice(iD(3537), "info:This is a message without values and a 32-bit stamp.\n"
); //exp: time: 842,150_450default: info:This is a message without values and a 32-bit stamp.
```

Some C-code lines contain Trice statements and comments starting with `//exp:` followed by the expected Trice tool output for that specific line. The **Go** testfunction collects these outputs in a slice together with the line numbers. Then for each found line number the execution of the **Go** function `func triceCheck(n int)` takes part, which in turn calls the CGO compiled C-function `TriceCheck(n)`. The now activated Trice C-code writes the generated trice bytes in a between **C** and **Go** shared buffer using the C-function `TriceWriteDeviceCgo`. After returning from the **Go** function `func triceCheck(n int)` and optionally calling `TriceTransfer` in deferred mode the Trice tool `triceLog()` function converts the Trice buffer bytes to the log string and compares the result with the expected data. The between **Go** and **C** shared buffer limits the executed Trices per line to one, because they use the same buffer from the beginning. This could be done better with an increment to allow several trices in one single line.

Because each test runs a different configuration, all possible combinations are testable.

### 38.6. Test Results

```
ms@DESKTOP-7P0EGPB MINGW64 ~/repos/trice (master)
$./testAll.sh
Thu, Dec 12, 2024 4:51:26 PM
This can take several minutes ...
? github.com/rokath/trice/internal/decoder [no test files]
? github.com/rokath/trice/internal/do [no test files]
? github.com/rokath/trice/internal/translator [no test files]
? github.com/rokath/trice/pkg/ant [no test files]
ok github.com/rokath/trice/cmd/trice 1.392s
ok github.com/rokath/trice/internal/args 0.415s
ok github.com/rokath/trice/internal/charDecoder 0.298s
ok github.com/rokath/trice/internal/com 15.845s
ok github.com/rokath/trice/internal/dumpDecoder 0.339s
ok github.com/rokath/trice/internal/emitter 0.326s
ok github.com/rokath/trice/internal/id 3.088s
ok github.com/rokath/trice/internal/keybcmdd 0.233s
ok github.com/rokath/trice/internal/link 0.196s
ok github.com/rokath/trice/internal/receiver 0.246s
? github.com/rokath/trice/internal/translator [no test files]
? github.com/rokath/trice/pkg/ant [no test files]
ok github.com/rokath/trice/cmd/trice 1.392s
ok github.com/rokath/trice/internal/args 0.415s
ok github.com/rokath/trice/internal/charDecoder 0.298s
ok github.com/rokath/trice/internal/com 15.845s
ok github.com/rokath/trice/internal/dumpDecoder 0.339s
ok github.com/rokath/trice/internal/emitter 0.326s
ok github.com/rokath/trice/internal/id 3.088s
ok github.com/rokath/trice/internal/keybcmdd 0.233s
ok github.com/rokath/trice/internal/link 0.196s
ok github.com/rokath/trice/internal/receiver 0.246s
ok github.com/rokath/trice/internal/trexDecoder 0.264s
ok github.com/rokath/trice/pkg/cipher 0.230s
ok github.com/rokath/trice/pkg/endian 0.161s
ok github.com/rokath/trice/internal/args 0.415s
ok github.com/rokath/trice/internal/charDecoder 0.298s
ok github.com/rokath/trice/internal/com 15.845s
ok github.com/rokath/trice/internal/dumpDecoder 0.339s
```

```
ok github.com/rokath/trice/internal/emitter 0.326s
ok github.com/rokath/trice/internal/id 3.088s
ok github.com/rokath/trice/internal/keybcmdd 0.233s
ok github.com/rokath/trice/internal/link 0.196s
ok github.com/rokath/trice/internal/receiver 0.246s
ok github.com/rokath/trice/internal/trexDecoder 0.264s
ok github.com/rokath/trice/pkg/cipher 0.230s
ok github.com/rokath/trice/pkg/endian 0.161s
ok github.com/rokath/trice/internal/id 3.088s
ok github.com/rokath/trice/internal/keybcmdd 0.233s
ok github.com/rokath/trice/internal/link 0.196s
ok github.com/rokath/trice/internal/receiver 0.246s
ok github.com/rokath/trice/internal/trexDecoder 0.264s
ok github.com/rokath/trice/pkg/cipher 0.230s
ok github.com/rokath/trice/pkg/endian 0.161s
ok github.com/rokath/trice/pkg/msg 0.157s
ok github.com/rokath/trice/pkg/tst 0.261s
ok github.com/rokath/trice/_test/be_dblB_de_tcobs_ua 123.142s
ok github.com/rokath/trice/_test/be_staticB_di_xtea_cobs_rtt32 123.159s
ok github.com/rokath/trice/internal/trexDecoder 0.264s
ok github.com/rokath/trice/pkg/cipher 0.230s
ok github.com/rokath/trice/pkg/endian 0.161s
ok github.com/rokath/trice/pkg/msg 0.157s
ok github.com/rokath/trice/pkg/tst 0.261s
ok github.com/rokath/trice/_test/be_dblB_de_tcobs_ua 123.142s
ok github.com/rokath/trice/_test/be_staticB_di_xtea_cobs_rtt32 123.159s
ok github.com/rokath/trice/pkg/msg 0.157s
ok github.com/rokath/trice/pkg/tst 0.261s
ok github.com/rokath/trice/_test/be_dblB_de_tcobs_ua 123.142s
ok github.com/rokath/trice/_test/be_staticB_di_xtea_cobs_rtt32 123.159s
ok github.com/rokath/trice/pkg/msg 0.157s
ok github.com/rokath/trice/_test/dblB_de_cobs_ua 122.964s
ok github.com/rokath/trice/_test/dblB_de_multi_cobs_ua 123.308s
ok github.com/rokath/trice/_test/be_dblB_de_tcobs_ua 123.142s
ok github.com/rokath/trice/_test/be_staticB_di_xtea_cobs_rtt32 123.159s
ok github.com/rokath/trice/_test/dblB_de_cobs_ua 122.964s
ok github.com/rokath/trice/_test/dblB_de_multi_cobs_ua 123.308s
ok github.com/rokath/trice/_test/dblB_de_cobs_ua 122.964s
ok github.com/rokath/trice/_test/dblB_de_multi_cobs_ua 123.308s
ok github.com/rokath/trice/_test/dblB_de_cobs_ua 122.964s
ok github.com/rokath/trice/_test/dblB_de_multi_cobs_ua 123.308s
ok github.com/rokath/trice/_test/dblB_de_cobs_ua 123.308s
ok github.com/rokath/trice/_test/dblB_de_multi_no_pf_ua 123.244s
ok github.com/rokath/trice/_test/dblB_de_multi_no_pf_ua 123.244s
ok github.com/rokath/trice/_test/dblB_de_multi_tcobs_ua 123.109s
ok github.com/rokath/trice/_test/dblB_de_multi_tcobs_ua 123.109s
ok github.com/rokath/trice/_test/dblB_de_multi_xtea_cobs_ua 123.213s
ok github.com/rokath/trice/_test/dblB_de_multi_xtea_tcobs_ua 123.001s
ok github.com/rokath/trice/_test/dblB_de_multi_xtea_cobs_ua 123.213s
ok github.com/rokath/trice/_test/dblB_de_multi_xtea_tcobs_ua 123.001s
ok github.com/rokath/trice/_test/dblB_de_no_pf_ua 123.092s
ok github.com/rokath/trice/_test/dblB_de_multi_xtea_tcobs_ua 123.001s
ok github.com/rokath/trice/_test/dblB_de_no_pf_ua 123.092s
ok github.com/rokath/trice/_test/dblB_de_tcobs_ua 122.324s
ok github.com/rokath/trice/_test/dblB_de_no_pf_ua 123.092s
ok github.com/rokath/trice/_test/dblB_de_tcobs_ua 122.324s
ok github.com/rokath/trice/_test/dblB_de_tcobs_ua 122.324s
ok github.com/rokath/trice/_test/dblB_de_xtea_cobs_ua 123.149s
ok github.com/rokath/trice/_test/dblB_de_xtea_tcobs_ua 122.883s
ok github.com/rokath/trice/_test/dblB_de_xtea_cobs_ua 123.149s
ok github.com/rokath/trice/_test/dblB_de_xtea_tcobs_ua 122.883s
ok github.com/rokath/trice/_test/dblB_di_no_pf_rtt32_de_cobs_ua 246.703s
ok github.com/rokath/trice/_test/dblB_de_xtea_tcobs_ua 122.883s
ok github.com/rokath/trice/_test/dblB_di_no_pf_rtt32_de_cobs_ua 246.703s
ok github.com/rokath/trice/_test/dblB_di_no_pf_rtt32_de_cobs_ua 246.703s
ok github.com/rokath/trice/_test/dblB_di_no_pf_rtt32_de_multi_cobs_ua 247.125s
ok github.com/rokath/trice/_test/dblB_di_no_pf_rtt32_de_multi_tcobs_ua 246.862s
ok github.com/rokath/trice/_test/dblB_di_no_pf_rtt32_de_tcobs_ua 246.531s
ok github.com/rokath/trice/_test/dblB_di_no_pf_rtt32_de_xtea_cobs_ua 247.072s
ok github.com/rokath/trice/_test/dblB_di_no_pf_rtt8_de_cobs_ua 246.639s
ok github.com/rokath/trice/_test/dblB_di_no_pf_rtt8_de_multi_cobs_ua 246.599s
ok github.com/rokath/trice/_test/dblB_di_no_pf_rtt8_de_multi_tcobs_ua 247.114s
ok github.com/rokath/trice/_test/dblB_di_no_pf_rtt8_de_tcobs_ua 246.851s
ok github.com/rokath/trice/_test/ringB_de_cobs_ua 123.578s
```

```

ok github.com/rokath/trice/_test/ringB_de_multi_tcobs_ua 123.517s
ok github.com/rokath/trice/_test/ringB_de_multi_xtea_cobs_ua 123.497s
ok github.com/rokath/trice/_test/ringB_de_multi_xtea_tcobs_ua 123.379s
ok github.com/rokath/trice/_test/ringB_de_nopf_ua 123.555s
ok github.com/rokath/trice/_test/ringB_de_tcobs_ua 123.300s
ok github.com/rokath/trice/_test/ringB_de_xtea_cobs_ua 123.487s
ok github.com/rokath/trice/_test/ringB_de_xtea_tcobs_ua 123.846s
ok github.com/rokath/trice/_test/ringB_di_cobs_rtt32_de_tcobs_ua 247.400s
ok github.com/rokath/trice/_test/ringB_di_cobs_rtt8_de_tcobs_ua 247.202s
ok github.com/rokath/trice/_test/ringB_di_nopf_rtt32_de_tcobs_ua 247.204s
ok github.com/rokath/trice/_test/ringB_di_nopf_rtt32_de_xtea_cobs_ua 246.818s
ok github.com/rokath/trice/_test/ringB_di_nopf_rtt8_de_tcobs_ua 247.006s
ok github.com/rokath/trice/_test/ringB_di_tcobs_rtt32_de_tcobs_ua 247.000s
ok github.com/rokath/trice/_test/ringB_di_xtea_cobs_rtt32_de_xtea_cobs_ua 246.872s
ok github.com/rokath/trice/_test/special_protect_dblB_de_tcobs_ua 0.444s
ok github.com/rokath/trice/_test/stackB_di_nopf_aux32 123.819s
ok github.com/rokath/trice/_test/stackB_di_nopf_aux8 123.830s
ok github.com/rokath/trice/_test/stackB_di_nopf_rtt32 123.912s
ok github.com/rokath/trice/_test/stackB_di_nopf_rtt8 123.976s
ok github.com/rokath/trice/_test/stackB_di_xtea_cobs_rtt8 123.719s
ok github.com/rokath/trice/_test/staticB_di_nopf_aux32 123.553s
ok github.com/rokath/trice/_test/staticB_di_nopf_aux8 123.551s
ok github.com/rokath/trice/_test/staticB_di_nopf_rtt32 123.596s
ok github.com/rokath/trice/_test/staticB_di_nopf_rtt8 123.618s
ok github.com/rokath/trice/_test/staticB_di_tcobs_rtt32 123.177s
ok github.com/rokath/trice/_test/staticB_di_tcobs_rtt8 123.353s
ok github.com/rokath/trice/_test/staticB_di_xtea_cobs_rtt32 123.126s

real 10m31.130s
user 0m0.000s
sys 0m0.015s

```

ms@DESKTOP-7P0EGPB MINGW64 ~/repos/trice (master)  
\$

## 38.7. Special tests

## 38.8. Test Cases

### 38.8.1. Folder Naming Convention

| Folder Name Part      | Meaning                                                                                                     |
|-----------------------|-------------------------------------------------------------------------------------------------------------|
| <code>testdata</code> | This is no test folder. It contains data common to all tests.                                               |
| <code>_...</code>     | Folder starting with an underscore <code>_</code> are excluded when <code>go test ./...</code> is executed. |
| <code>_di_</code>     | direct mode                                                                                                 |
| <code>_de_</code>     | deferred mode                                                                                               |
| <code>special_</code> | a test, not using <code>./testdata/triceCheck.c</code>                                                      |
| <code>staticB_</code> | static buffer, direct mode only possible                                                                    |
| <code>stackB_</code>  | stack buffer, direct mode only possible                                                                     |
| <code>ringB_</code>   | ring buffer, deferred mode and optional parallel direct mode                                                |
| <code>dblB_</code>    | double buffer, deferred mode and optional parallel direct mode                                              |
| <code>_rtt8_</code>   | (simulated) SEGGER_RTT byte transfer                                                                        |
| <code>_rtt32_</code>  | (simulated) SEGGER_RTT word transfer                                                                        |
| <code>_—</code>       | direct and deferred mode together                                                                           |
| <code>_xtea_</code>   | with encryption, otherwise without encryption                                                               |
| <code>_tcobs</code>   | TCOBS package framing                                                                                       |
| <code>_cobs</code>    | COBS package framing                                                                                        |

| Folder Name Part | Meaning                                                                                                  |
|------------------|----------------------------------------------------------------------------------------------------------|
| _nopf            | no package framing                                                                                       |
| _multi_          | Usually each Trice is handled separately. In multi mode, groups of available Trices are framed together. |
| _ua              | simulated UART A output (for deferred modes)                                                             |

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## 39. Test Issues

Test folders starting with **ERROR\_** have issues. These cases are **usable** on the target. These tests fail for an unknown reason. Probably it is a test implementation issue. Especially when XTEA is used in one output but not in the other, the tests fail.

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## 40. Add-On Hints

### 40.1. Trice on LibOpenCM3

- This is a OpenCM3\_STM32F411\_Nucleo Contribution from [kraiskil](#).
- See also pull request [#269](#).
- It is here because the code need some re-work to be compatible with Trice version 1.0.

[LibOpenCM3](#) is a hardware abstraction library for many microcontrollers.

This is an example using STM's [STM32F411 Nucleo](#) board.

--> This code uses a legacy Trice version and needs adaption!

#### 40.1.1. Prerequisites

- Suitable ARM GCC cross compiler ([arm-none-eabi-gcc](#)) found in your system's PATH
- GNU Make, or compatible
- Environment variable [OPENCM3\\_DIR](#) points to the base install of libopencm3. This is e.g. the libopencm3 source directory, if you also built it in the source directory.
- OpenOCD

#### 40.1.2. triceConfig.h

```
/*! \file triceConfig.h
\author Thomas.Hoehenleitner [at] seerose.net
LibOpenCM3 adaptation by Kalle Raiskila.
***** */

#ifndef TRICE_CONFIG_H_
#define TRICE_CONFIG_H_

#ifndef __cplusplus
extern "C" {
#endif

#include <stdint.h>
#include <libopencm3/cm3/cortex.h>
#include <libopencm3/stm32/gpio.h>
#include <libopencm3/stm32/usart.h>

// Local (to this demo) time keeping functions
#include "time.h"

#define TRICE_UART_USART2 //!< Enable and set USART for serial output.
// The alternative, TRICE_RTT_CHANNEL is not available with OpenCM3
// #define TRICE_RTT_CHANNEL 0

// Timestamping function to be provided by user. In this demo from time.h
```



```

///! Command line similar to: `trice log -p COM1 -baud 115200`
#ifndef TRICE_MODE == 201
#define TRICE_CYCLE_COUNTER 0 //! Do not add cycle counter, The TRICE macros are a bit faster.
Lost TRICEs are not detectable by the trice tool.
#define TRICE_ENTER //! TRICE_ENTER is the start of TRICE macro. The TRICE macros are
a bit faster. Inside interrupts TRICE macros forbidden.
#define TRICE_LEAVE //! TRICE_LEAVE is the end of TRICE macro.
#define TRICE_HALF_BUFFER_SIZE 2000 //!< This is the size of each of both buffers. Must be able to
hold the max TRICE burst count within TRICE_TRANSFER_INTERVAL_MS or even more, if the write out speed
is small. Must not exceed SEGGER BUFFER_SIZE_UP
#define TRICE_SINGLE_MAX_SIZE 800 //!< must not exceed TRICE_HALF_BUFFER_SIZE!
#endif // #if TRICE_MODE == 201

//-
////////////////-
// Headline info
//-
//!

#endif TRICE_HALF_BUFFER_SIZE
#define TRICE_BUFFER_INFO
do {
 TRICE32(Id(0), "att: Trice 2x half buffer size:%4u ", TRICE_HALF_BUFFER_SIZE); \
} while (0)
#else
#define TRICE_BUFFER_INFO
\
do {
\
 TRICE32(Id(0), "att:Single Trice Stack buf size:%4u", TRICE_SINGLE_MAX_SIZE +
TRICE_DATA_OFFSET); \
} while (0)
#endif

//! This is usable as the very first trice sequence after restart. Adapt and use it or ignore it.
#define TRICE_HEADLINE
 TRICE0(Id(0), "s: \n"); \
 TRICE8(Id(0), "s: NUCLEO-F411RE TRICE_MODE %3u \n", TRICE_MODE); \
 TRICE0(Id(0), "s: \n"); \
 TRICE0(Id(0), "s: "); \
 TRICE_BUFFER_INFO; \
 TRICE0(Id(0), "s: \n"); \
 TRICE0(Id(0), "s: \n");

//-
////////////////-
// Compiler Adaption
//-

#if defined(__GNUC__) /* gnu compiler ##### */
#define TRICE_INLINE static inline //! used for trice code

#define ALIGN4 //!< align to 4 byte boundary preamble
#define ALIGN4_END __attribute__((aligned(4))) //!< align to 4 byte boundary post declaration

//! TRICE_ENTER_CRITICAL_SECTION saves interrupt state and disables Interrupts.
#define TRICE_ENTER_CRITICAL_SECTION \
{ \
 uint32_t old_mask = cm_mask_interrupts(1); \
}

//! TRICE_LEAVE_CRITICAL_SECTION restores interrupt state.
#define TRICE_LEAVE_CRITICAL_SECTION \
{ \
 cm_mask_interrupts(old_mask); \
}

```

```
#else
#error unknown compiler
#endif // compiler adaptions #####

//#####
#####

// Optical feedback: Adapt to your device.
//

TRICE_INLINE void ToggleOpticalFeedbackLED(void) {
 // The only user controllable LED available on the
 // Nucleo is LD2, on port A5. This is set up in main.c
 gpio_toggle(GPIOA, GPIO5);
}

//#####
#####

// UART interface: Adapt to your device.
//

#ifndef TRICE_UART

/// Check if a new byte can be written into trice transmit register.
/// \retval 0 == not empty
/// \retval !0 == empty
/// User must provide this function.
TRICE_INLINE uint32_t triceTxDataRegisterEmpty(void) {
 uint32_t reg = USART_SR(TRICE_UART);
 return (reg & USART_SR_TXE);
}

/// Write value v into trice transmit register.
/// \param v byte to transmit
/// User must provide this function.
TRICE_INLINE void triceTransmitData8(uint8_t v) {
 usart_send_blocking(TRICE_UART, v);
 ToggleOpticalFeedbackLED();
}

/// Allow interrupt for empty trice data transmit register.
/// User must provide this function.
TRICE_INLINE void triceEnableTxEmptyInterrupt(void) {
 usart_enable_tx_interrupt(TRICE_UART);
}

/// Disallow interrupt for empty trice data transmit register.
/// User must provide this function.
TRICE_INLINE void triceDisableTxEmptyInterrupt(void) {
 usart_disable_tx_interrupt(TRICE_UART);
}

#endif // #ifndef TRICE_UART

#####

// Default TRICE macro bitwidth: 32 (optionally adapt to MCU bit width)
//

#define TRICE_1 TRICE32_1 //!< Default parameter bit width for 1 parameter count TRICE is 32,
change for a different value.
#define TRICE_2 TRICE32_2 //!< Default parameter bit width for 2 parameter count TRICE is 32,
change for a different value.
#define TRICE_3 TRICE32_3 //!< Default parameter bit width for 3 parameter count TRICE is 32,
change for a different value.
#define TRICE_4 TRICE32_4 //!< Default parameter bit width for 4 parameter count TRICE is 32,
change for a different value.
#define TRICE_5 TRICE32_5 //!< Default parameter bit width for 5 parameter count TRICE is 32,
change for a different value.
```

```

#define TRICE_6 TRICE32_6 //!< Default parameter bit width for 6 parameter count TRICE is 32,
change for a different value.
#define TRICE_7 TRICE32_7 //!< Default parameter bit width for 7 parameter count TRICE is 32,
change for a different value.
#define TRICE_8 TRICE32_8 //!< Default parameter bit width for 8 parameter count TRICE is 32,
change for a different value.
#define TRICE_9 TRICE32_9 //!< Default parameter bit width for 9 parameter count TRICE is 32,
change for a different value.
#define TRICE_10 TRICE32_10 //!< Default parameter bit width for 10 parameter count TRICE is 32,
change for a different value.
#define TRICE_11 TRICE32_11 //!< Default parameter bit width for 11 parameter count TRICE is 32,
change for a different value.
#define TRICE_12 TRICE32_12 //!< Default parameter bit width for 12 parameter count TRICE is 32,
change for a different value.

//

#ifndef __cplusplus
}
#endif

#endif /* TRICE_CONFIG_H_ */

```

#### 40.1.3. main.c

```

/*
 * Demo to test/show TRICE usage in a libopencm3
 * environment.
 */

#include <libopencm3/cm3/systick.h>
#include <libopencm3/stm32/gpio.h>
#include <libopencm3/stm32/exti.h>
#include <libopencm3/stm32/usart.h>
#include <libopencm3/stm32/rcc.h>
#include <libopencm3/cm3/nvic.h>

#include <stdint.h>
void msleep(uint32_t delay);
uint32_t wallclock_ms(void);

#include "trice.h"

static void hardware_setup(void)
{
 /* Set device clocks from opencm3 provided preset.*/
 const struct rcc_clock_scale *clocks = &rcc_hsi_configs[RCC_CLOCK_3V3_84MHZ];
 rcc_clock_setup_pll(clocks);

 /* Set up driving the LED connected to port A, pin 5. */
 rcc_periph_clock_enable(RCC_GPIOA);
 gpio_mode_setup(GPIOA, GPIO_MODE_OUTPUT, GPIO_PUPD_NONE, GPIO5);

 /* User-button is connected to port C, pin 13. Set up button push
 * to cause an interrupt. */
 gpio_mode_setup(GPIOC, GPIO_MODE_INPUT, GPIO_PUPD_NONE, GPIO13);
 rcc_periph_clock_enable(RCC_SYSCFG); // clock for the EXTI handler
 nvic_enable_irq(NVIC_EXTI15_10_IRQ);
 exti_select_source(EXTI13, GPIOC);
 exti_set_trigger(EXTI13, EXTI_TRIGGER_FALLING);
 exti_enable_request(EXTI13);

 /* USART2 is connected to the nucleo's onboard ST-Link, which forwards
 * it as a serial terminal over the ST-Link USB connection.
 * This UART is given to the Trice data. */
 rcc_periph_clock_enable(RCC_USART2);
 usart_set_baudrate(USART2, 115200);
}

```

```
uart_set_databits(USART2, 8);
uart_set_stopbits(USART2, USART_STOPBITS_1);
uart_set_mode(USART2, USART_MODE_TX);
uart_set_parity(USART2, USART_PARITY_NONE);
uart_set_flow_control(USART2, USART_FLOWCONTROL_NONE);

// Enable UART2 interrupts in the system's interrupt controller
// but do NOT enable generating interrupts in the UART at this
// time. Let Trice enable them with triceEnableTxEmptyInterrupt()
nvic_enable_irq(NVIC_USART2_IRQ);
//uart_enable_tx_interrupt(USART2);
uart_enable(USART2);

/* Configure USART TX pin only. We don't get any input via the TRICE
 * channel, so the RX pin can be left unconnected to the USART2 */
gpio_mode_setup(GPIOA, GPIO_MODE_AF, GPIO_PUPD_NONE, GPIO2);
gpio_set_af(GPIOA, GPIO_AF7, GPIO2);

/* Enable systick at a 1mS interrupt rate */
systick_set_reload(84000);
systick_set_clocksource(STK_CSR_CLKSOURCE_AHB);
systick_counter_enable();
systick_interrupt_enable();
}

///////////
// Time handling utilities
static volatile uint32_t system_millis;

/* "sleep" for delay milliseconds */
void msleep(uint32_t delay)
{
 uint32_t wake = system_millis + delay;
 while (wake > system_millis);
}

uint32_t wallclock_ms(void)
{
 return system_millis;
}

///////////
// Interrupt handlers
// These are weak symbols in libopencm3
// that get overridden here.

// Trice USART
void usart2_isr(void)
{
 #if TRICE_MODE == 200
 triceServeTransmit();
 #endif
}

// External interrupts on pins 10–15, all ports.
// Only PC13 (User button on Nucleo) is enabled in this program.
void exti15_10_isr(void)
{
 exti_reset_request EXTI13;
 #if TRICE_MODE == 200
 TRICE(Id(0), "Button press at, %d\n", system_millis);
 #endif
}

// Systick timer set to 1ms
void sys_tick_handler(void)
{
 system_millis++;
 #if TRICE_MODE == 200
 // Start sending what is currently in the Trice transmit buffer
 triceTriggerTransmit();
}
```

```

#endif
}

int main(void)
{
 hardware_setup();
 TRICE_HEADLINE;
 while (1) {
 msleep(1000);

 // Depending on mode, either print this string to
 // UART (mode 0), or the Trice write buffer (mode 200).
 TRICE(Id(0), "Hello, TRICE, %d\n", 42);

 // TRICE("") with a string parameter only is problematic.
 // See discussion on https://github.com/rokath/trice/issues/279
 // TRICE0("") works in either case
#ifndef __STRICT_ANSI__
 // if compiled with e.g. --std=c99
 TRICE0(Id(0), "Hello, TRICE\n");
#else
 TRICE(Id(0), "Hello, TRICE\n");
 TRICE0(Id(0), "Hello, TRICE0()\n");
#endif

#if TRICE_MODE == 200
 // Swap Trice transmit/write ping-pong buffers.
 // Stuff printed with TRICE() since the last
 // call to TriceTransfer() will be sent once
 // triceTriggerTransmit() is called.
 TriceTransfer();
#endif
 }

 return 0;
}

```

#### 40.1.4. nucleo-f411re.ld

```

/* Use the LibOpenCM3-provided defaults for the linker details.
 */
MEMORY
{
 rom (rx) : ORIGIN = 0x08000000, LENGTH = 512K
 ram (rwx) : ORIGIN = 0x20000000, LENGTH = 128K
}

INCLUDE cortex-m-generic.ld

```

#### 40.1.5. Makefile

```

Makefile for compiling the Trice demo on LibOpenCM3
for STM32F411-Nucleo boards
CC=arm-none-eabi-gcc
CFLAGS=-O0 -std=c99 -ggdb3
CFLAGS+=-mthumb -mcpu=cortex-m4 -mfloating-abi=hard -mfpu=fpv4-sp-d16
CFLAGS+=-Wextra -Wshadow -Wimplicit-function-declaration -Wredundant-decls -Wmissing-prototypes -Wstrict-prototypes
CFLAGS+=-fno-common -ffunction-sections -fdata-sections -MD -Wall -Wundef
CFLAGS+=-DSTM32F4 -I/home/kraiskil/stuff/libopencm3/include
These two are for trice.h and triceConfig.h
CFLAGS+=-I../../pkg/src/ -I.

LFLAGS=-L${OPENCM3_DIR}/lib -lopencm3_stm32f4 -lm -Wl,--start-group -lc -lgcc -lnosys -Wl,--end-group
LFLAGS+=-T nucleo-f411re.ld

```

```
LFLAGS+=--static -nostartfiles
LFLAGS+=-Wl,-Map=memorymap.txt

all: direct_mode.elf irq_mode.elf
.PHONY: flash clean

Annotate Trice-enabled code.
trice does this annotation in-place, so here we take
a copy before running trice.
I.e. write TRICE macros in foo.c, and this will generate
the TRICE(Id(1234) ..) macros into foo.trice.c
%.trice.c: %.c til.json
 cp -f $< $<.bak
 trice update
 cp -f $< $@
 cp -f $<.bak $<

trice expects this file to exist, can be empty.
til.json:
 touch til.json

direct_mode.elf: main.trice.c ../../pkg/src/trice.c
 ${CC} ${CFLAGS} $^ -o $@ ${LFLAGS} -DTRICE_MODE=0

flash_direct_mode: direct_mode.elf
 openocd -f interface/stlink-v2.cfg -f target/stm32f4x.cfg -c "program direct_mode.elf verify reset
exit"

irq_mode.elf: main.trice.c ../../pkg/src/trice.c
 ${CC} ${CFLAGS} $^ -o $@ ${LFLAGS} -DTRICE_MODE=200

flash_irq_mode: irq_mode.elf
 openocd -f interface/stlink-v2.cfg -f target/stm32f4x.cfg -c "program irq_mode.elf verify reset
exit"

clean:
 @rm -f *.elf til.json main.trice.c
```

#### 40.1.6. Usage

- Run `make direct_mode.elf` to compile with Trice mode 0.
- Run `make flash_direct_mode` to program the board.
- Run trice: `trice l -p /dev/ttyACM0`.

#### 40.2. Get all project files containing Trice messages

```
cat demoLI.json | grep '"File":' | sort | uniq
 "File": "_test/_ringB_protect_de_tcobs_ua/TargetActivity.c",
 "File": "_test/_special_dbkB_de_tcobs_ua/TargetActivity.c",
 "File": "_test/special_for_debug/TargetActivity.c",
 "File": "_test/special_protect_dbkB_de_tcobs_ua/TargetActivity.c",
 "File": "_test/testdata/triceCheck.c",
 "File": "examples/F030_inst/Core/Src/stm32f0xx_it.c",
 "File": "examples/G0B1_inst/Core/Src/main.c",
 "File": "examples/G0B1_inst/Core/Src/stm32g0xx_it.c",
 "File": "examples/L432_inst/Core/Inc/triceConfig.h",
 "File": "examples/L432_inst/Core/Src/main.c",
 "File": "examples/L432_inst/Core/Src/stm32l4xx_it.c",
 "File": "examples/exampleData/triceExamples.c",
 "File": "examples/exampleData/triceLogDiagData.c",
```

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## 41. Trice User Manual Changelog

► Details (click to expand)

| Date        | Version | Comment       |
|-------------|---------|---------------|
| 2024-DEC-01 | 0.0.0   | Initial Draft |

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